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THE PHILOSOPHY OF NATURAL HISTORY.

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PREFACE.

EVERY Preface, beſide occaſional or explanatory remarks, ſhould contain not only the general deſign of the work, but the motives and circumſtances which induced the author to write upon that particular ſubject. If this plan had been univerſally obſerved, prefaces would have exhibited a ſhort, but a curious and uſeful, hiſtory both of literature and of authors. Influenced by this idea, I ſhall give a very compendious account of the origin, deſign, and progreſs of the following work.

About fifteen years ago, in a converſation with the late worthy, reſpectable, and ingenious Lord KAMES, upon the too general neglect of natural knowledge, his Lordſhip ſuggeſted the idea of compoſing a book on the PHILOSOPHY OF NATURAL HISTORY. In a work of this kind, he propoſed that the productions of Nature, which to us are almoſt infinite, ſhould, inſtead of being treated of individually, be arranged under general heads; that, in each of theſe diviſions, the known facts, as well as reaſonings, ſhould be collected and methodiſed in the form of regular diſcourſes; that as few technical terms as poſſible ſhould be employed; and

and that all the uſeful and amuſing views ariſing from the different ſubjects ſhould be exhibited in ſuch a manner as to convey both pleaſure and information.

This taſk his Lordſhip was pleaſed to think me not altogether unqualified to attempt. The idea ſtruck me. I thought that a work of this kind, if executed even with moderate abilities, might excite a taſte for examining the various objects which every where ſolicit our attention. A habit of obſervation refines our feelings. It is a ſource of intereſting amuſement, prevents idle or vicious propenſities, and exalts the mind to a love of virtue and of rational entertainment. I likewiſe reflected, that men of learning often betray an ignorance on the moſt common ſubjects of Natural Hiſtory, which it is painful to remark.

I have been occaſionally employed, ſince the period which I have mentioned, in collecting and digeſting materials from the moſt authentic ſources. Theſe materials I have interſperſed with ſuch obſervations, reflections, and reaſonings, as occurred to me from conſidering the multifarious ſubjects of which I have ventured to treat. I knew that a deliberate peruſal of the numerous writers from Ariſtotle downwards, would require a conſiderable portion of time. But the avocations of buſineſs, and the tranſlating of a work ſo voluminous as the *Natural Hiſtory of the* COUNT DE BUFFON, rendered my progreſs much ſlower than I wiſhed. I now, however, with much diffidence, ſubmit my labours to public opinion. An examination of the *Contents*, however, will convey a more clear idea

of

of the nature of the work than a multiplicity of words. But I thought it proper to prefix a ſhort account of the circumſtances and motives which induced me to engage in an undertaking ſo extenſive, and ſo difficult to perform with tolerable ſucceſs.

With regard to the manner of writing, it is perhaps impoſſible for a North Briton, in a work of any extent, to avoid what are called *Scotticiſms*. But I have endeavoured to be every where conſpicuous, and to ſhun every ſentiment or expreſſion which might have a tendency to injure ſociety, or to hurt the feelings of individuals.

Indulgent readers, though they muſt perceive errors and imperfections, will naturally make ſome allowance for the variety of reſearch, and the labour of condenſing ſo much matter into ſo ſmall a compaſs. He is a bad author, it has been ſaid, who affords neither an aphoriſm nor a motto.

I cannot refrain from mentioning a circumſtance which has often made me uneaſy. The expectations of ſome friends were higher than I was conſcious my abilities could reach.

Upon the whole, the general deſign of this publication is, to convey to the minds of youth, and of ſuch as may have paid little attention to the ſtudy of Nature, a ſpecies of knowledge which it is not difficult to acquire. This knowledge will be a perpetual and inexhauſtible ſource of manly pleaſures; it will afford innocent and virtuous amuſement, and will occupy agreeably the leiſure or vacant hours of life.

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THE

PHILOSOPHY

OF

NATURAL HISTORY.

CHAP. I.

Diſtinguiſhing characters of Animals, Plants, and Minerals. —The Analogies between the plant and animal, ariſing from their ſtructure and organs, their growth and nouriſhment, their diſſemination and decay.

NATURAL Bodies, when viewed as they have a relation to man, are marked with characters ſo apparent, that they eſcape not the obſervation of the moſt unenlightened minds. In a ſyſtem where all the conſtituent parts have a reciprocal dependence, and are connected by relations ſo ſubtile as to elude the perception of animals, ſuch obvious characters were indiſpenſible. Without them, neither the affairs of human life, nor the functions of the brute creation, could be carried on. Characters of this kind are accommodated to the apprehenſion of brutes, and of vulgar men.

But, when the productions of nature are more closely examined; when they are scrutinized by the eye of philosophy, the number of their relations and differences is discovered to be almost infinite; and their shades of discrimination are often so delicate, that no sense can perceive them. Nothing, apparently, is more easy than to distinguish an animal from a plant; and yet the proper distinction has puzzled the most acute inquirers, and, perhaps, exceeds the limits of human capacity.

'A plant,' says Jungius, 'is a *living*, but not a *sentient* 'body, which is fixed in a determined place, and grows, 'increases in size, and propagates its species*.' In this definition, living powers are ascribed to vegetables; but they are denied the faculty of sensation. Life, without some degree of sensation, is an incomprehensible idea. An animal limited to the sense of feeling alone, is the lowest conception we can form of life. Deprive this being of the only sense it possesses, and, though its figure should remain, we would instantly conclude it to be as inanimate as a stone. The life attributed to plants, seems to be nothing more than an analogical deduction from their growth, nutrition, continuation of their species, and similar circumstances.

Ludwig defines vegetables to be 'Natural bodies, al'ways endowed with the same form, but deprived of the 'power of local motion†.' Every branch of this definition is, with equal propriety, applicable to precious stones, salts, and some animals; and, therefore, requires no farther attention.

Sir Charles Linnæus, in his Fundamenta Botanica, intends to discriminate the three kingdoms of Nature in two lines. 'Stones,' says he, '*grow*; vegetables grow, and '*live*; animals grow, live, and *feel* §.' This is an assemblage of words, the meaning of which is entirely perverted. The idea of growth implies nutrition and expansion by the intervention of organs. The magnitude of stones may be augmented by an accretion of new matter; but, this is not growth, or expansion of parts. The second

* Raii Hist. Plant. p. 1. S.

† Ludwig, Phil. Bot. p. 1 S.

§ Fund. Bot. § 3. S.

cond definition, ‘That vegetables grow and *live*,’ is equally inaccurate. Inſtead of proving the life of plants, Linnæus takes it for granted, and makes it the characteriſtic between vegetables and brute matter. The third, ‘That animals grow, live, and *feel*,’ is not leſs exceptionable. Growth, life, and mere ſenſation, convey the moſt ignoble notions of animated beings. From this definition, we would be led to imagine, that Linnæus meant to deſcribe the condition of a polypus, or an oyſter. All animals, it is true, grow, live, and feel: But, theſe are only the paſſive properties of animals. The definition includes none of thoſe inſtinctive, intellectual, and active powers which exalt the animal above the vegetable, and ſo eminently diſtinguiſh the different tribes from each other.

Theſe and many other abortive attempts have been made to aſcertain the preciſe boundaries between the animal and vegetable. Definitions have been the perpetual aim of moſt writers on this ſubject. But, definitions, when applied to natural objects, muſt always be vague and eluſory. We know not the principle of animal life. We are equally ignorant of the eſſential cauſe of vegetable exiſtence. It is vain, therefore, to dream of being able to define what we never can know. We may, however, diſcover ſome qualities common to the animal as well as to the vegetable.

Senſation, motion, and ſtructure of parts, give animals a more extenſive range in their connection with external objects. A certain portion of intellect, joined to the vital principle, ſeem to be the moſt diſtinguiſhing properties of animals, and to conſtitute their eſſence, or being. Animals will, determine, act, and have a communication with diſtant objects by their ſenſes. They have the laws of nature, in ſome meaſure, at command. They protect themſelves from injury by employing force, ſwiftneſs, addreſs, and cunning. But, vegetables remain fixed in the ſame place, and are ſubject to every thing that moves. Animals eat at intervals; their food requires time for digeſtion, and to anſwer the complicated purpoſes of ſecretion and nutrition. The ſtructure of plants is more ſimple: They receive perpetual nouriſhment without injury.

jury. Animals ſearch for, and ſelect, particular kinds of food. But, plants muſt receive whatever is brought to them by the different elements. Animals exiſt on the ſurface and in the interior parts of the earth, in the air, in water, in the bodies of men and other animals, in the internal parts of plants, and even in ſtones. But, if we except a few aquatics, plants are fixed to the earth by roots.

All animals, it has been affirmed, have a heart, or particular fountain, for propelling and diſtributing their fluids to the different parts of their bodies: But, caterpillars, and many other inſects, have no ſuch general receptacle *.

The loco-motive faculty has been conſidered as peculiar to animals. But, even this character is extremely ſuſpicious. Oyſters, ſea-nettles, the gall-inſects, and a variety of other animals, can hardly be ſaid to enjoy the power of local motion. Many ſpecies remain forever fixed to the rocks on which they are produced, and have no motion but that of extending or contracting their bodies. Beſides, examples of different kinds of motion are diſcoverable in the vegetable kingdom. When the roots of a tree meet with a ſtone, or any other obſtruction to their motion, in order to avoid it, they change their former direction. They turn from barren to fertile earth, which indicates ſomething analogous to a ſelection of food. Like the polypus, plants, when confined in a houſe, uniformly bend toward the window, or aperture, through which the rays of light are introduced.

The ſenſitive plant poſſeſſes the faculty of motion in an eminent degree. The ſlighteſt touch makes its leaves ſuddenly ſhrink, and, together with the branch, bend down toward the earth. But, the moving plant, or hedyſarum movens †, of which there are ſpecimens in the botanic garden of Edinburgh, furniſhes the moſt aſtoniſhing example of vegetable motion. It is a native of the Eaſt-Indies. Its movements are not excited by the contact of external bodies, but ſolely by the influence of the ſun's rays. The motions of this plant are confined to the leaves, which are ſupported

* The ſubject of this paragraph ſhall be examined in another place.

† The Hedyſarum *gyrans* of Linnæus.

supported by long flexible foot-stalks. When the sun shines, the leaves move briskly in every direction. Their general motion, however, is upward and downward: But, they not unfrequently turn almost round; and, then, their foot-stalks are evidently twisted. These motions go on incessantly, as long as the heat of the sun continues: But, they cease during the night, and when the weather is cold and cloudy. Our wonder is excited by the rapidity and constancy of the movements peculiar to this plant. The frequency, however, of similar motions in other plants, renders it probable that the leaves of all vegetables move, or are agitated by the rays of the sun, though many of these movements are too slow for our perception.

The American plant called *dionæa muscipula* *, or *Venus's fly-trap*, affords another instance of rapid vegetable motion. Its leaves are jointed, and furnished with two rows of strong prickles. Their surfaces are covered with a number of minute glands, which secrete a sweet liquor, and allure the approach of flies. When these parts are touched by the legs of a fly, the two lobes of the leaf instantly rise up, the rows of prickles lock themselves fast together, and squeeze the unwary animal to death. If a straw or a pin be introduced between the lobes, the same motions are excited.

When a seed is sown in a reversed position, the young root turns downward to enter the earth, and the stem bends upward into the air. Confine a young stem to an inclined position, and its extremity will soon assume its former perpendicular direction. Twist the branches of any tree in such a manner that the inferior surfaces of the leaves are turned toward the sky, and you will, in a short time, perceive that all these leaves resume their original position. These motions are performed sooner or later, in proportion to the degree of heat, and the flexibility of the leaves. Many leaves, as those of the mallow †, follow the course of the sun. In the morning, their superior surfaces are presented to the east; at noon, they regard the south;

* This singular and beautiful vegetable is a native of the bogs, or marshy situations, of Carolina.

† Malva.

fouth; and, when the fun fets, they are directed to the weft. During the night, or in rainy weather, thefe leaves are horizontal; and their inferior furfaces are turned toward the earth*.

What has been denominated the Sleep of Plants, affords an inftance of another fpecies of vegetable motion. The leaves of many plants fold up during the night; but, at the approach of the fun, they expand with renewed vigour. The common appearances of moft vegetables are fo changed in the night, that it is difficult to recognife the different kinds, even by the affiftance of light.

The modes of folding in the leaves, or of fleeping, are extremely various. But, it is worthy of remark, that they all difpofe themfelves fo as to give the beft protection to the young ftems, flowers, buds, or fruit. The leaves of the tamarind-tree † contract round the tender fruit, and protect it from the nocturnal cold. The caffia or fenna, the glycine, and many of the papilionaceous plants, contract their leaves in a fimilar manner. The leaves of the chickweed ‖, of the afclepias, atriplex §, &c. are difpofed in oppofite pairs. During the night, they rife perpendicularly, and join fo clofe at the top, that they conceal the flowers. The leaves of the fida¶ or althæa Theophrafti, of the ayenia, and œnothera **, are placed alternately. Though horizontal, or even depending, during the day, at the approach of night they rife, embrace the ftem, and protect the tender flowers. The leaves of the folanum ††, or nightfhade, are horizontal during the day; but, in the night, they rife, and cover the flowers. The Egyptian vetch ‖‖ erects its leaves during the night, in fuch a manner that each pair feem to be one leaf only. The leaves of the white lupine §§, in the ftate of fleep, hang down, and protect the young buds from being injured by the nocturnal air.

These

* On thefe fubjects, the beautiful experiments of that enlightened philofoper Mr. Bonnet, deferve to be confulted. See his *Recherches fur l'ufage des feuilles dans les plantes*, &c. a work in every page of which the genius and the learning of its author are eminently confpicuous.

† Tamarindus *indica*.
‖ Alfine *media*.
§ Atriplex *hortenfis*.
¶ Sida *Abutilon*.
** Œnothera *molliffima*.
†† Solanum *Melongena*.
‖‖ Abrus *precatorius*.
§§ Lupinus *albus*.

Theſe and ſimilar motions are not peculiar to the leaves of plants. The flowers have alſo the power of moving. During the night, many of them are incloſed in their calixes. Some flowers, as thoſe of the German ſpurge *, geranium ſtriatum, and common whitlow-graſs †, when aſleep, hang their mouths toward the earth, to prevent the noxious effects of rain, or dew.

The cauſe of theſe movements which conſtitute the ſleep of plants, has been aſcribed to the preſence or abſence of the ſun's rays. In ſome of the examples I have given, the motions produced are evidently excited by heat. But, plants kept in a hot-houſe, where an equal degree of heat is preſerved both day and night, fail not to contract their leaves, or to ſleep, in the ſame manner as when they are expoſed to the open air. This fact evinces, that the ſleep of plants is rather owing to a peculiar law, than to a quicker or ſlower motion of their juices.

A ſtomach and brain have been reckoned eſſential characteriſtics of the animal; and plants are ſaid to poſſeſs nothing analogous to theſe organs. But, the polypus has no ſtomach; or rather, like vegetables, its whole body may be conſidered as a ſtomach. Its internal cavity contains no viſcera; and, when this animal is turned outſide in, it ſtill continues to live, and to digeſt its food, in the ſame manner as if it had received no injury. The mode by which plants are nouriſhed is extremely analogous. They imbibe food by the roots, the trunk, the branches, the leaves, and the flowers. Inſtead, therefore, of having no ſtomach, their whole ſtructure is ſtomach. With regard to the brain, the polypus, and many other inſects, are deprived of that organ. Hence, neither ſtomach nor brain are eſſential characters which diſcriminate the animal from the vegetable.

But, all animals are endowed with ſenſation, or at leaſt with irritability, which laſt has been conſidered as a diſtinctive character of animal life. Senſation implies a diſtinct perception of pleaſure, and pain. We infer the exiſtence of ſenſation in organized bodies, when we perceive

* Euphorbia. † Draba *verna* and *alpina*.

ceive that they have organs ſimilar to our own, or when they act, in certain circumſtances, in the ſame manner as we act. If an organized being has eyes, ears, and a noſe, we naturally conclude that it enjoys the ſame ſenſations as theſe organs convey to us. If we ſee another being, whoſe ſtructure exhibits nothing analogous to our organs of ſenſation, contracting with rapidity when touched, directing its body uniformly to the light, ſeizing ſmall inſects with *tentacula*, or a kind of arms, and conveying them into an aperture placed at its anterior end, we heſitate not to pronounce that it is animated. Cut off its arms, deprive it of the faculty of contracting and extending its body, the nature of this being will not be changed; but we will be unable to determine whether it poſſeſſes any portion of life. This is nearly the condition of the ſmall ſections of a polypus, before their heads begin to grow. The wheel-animal, the eels in blighted wheat, and the ſnails recorded in the Philoſophical Tranſactions, afford inſtances of every appearance of ſenſation, or even of irritability, being ſuſpended, not for months, but for ſeveral years, and yet the life of theſe animals is not extinguiſhed; for, they uniformly revive upon a proper application of moiſture.

Theſe and ſimilar facts ſhow, that we are entirely ignorant of the eſſence and properties of life. What life really is, ſeems too ſubtile for our underſtanding to conceive, or our ſenſes to diſcern. If we have no other criterions to diſtinguiſh life, than motion, ſenſation, and irritability, the animals juſt mentioned continued for years in a ſtate which every man would pronounce to have been perfectly dead. It is poſſible, therefore, that life may exiſt in many bodies which are commonly thought to be as inanimate as ſtones. Hence, it would be raſh to exclude plants from every ſpecies of ſenſation. The degrees of ſenſation decreaſe imperceptibly from man to the ſea-nettle, gall-inſects, and what are called the moſt imperfect animals. Every vegetable, as well as the ſenſitive plant, ſhrinks when wounded. But, in moſt of them, the motion is too ſlow for our perception. When trees grow near a ditch, the roots which proceed in a direction that would neceſſarily bring them into the open air, inſtead of continuing this

this noxious progreſs, ſink below the level of the ditch, then ſhoot acroſs, and regain the ſoil on the oppoſite ſide. When a root is uncovered, without expoſing it to much heat, and a wet ſpunge is placed near it, but in a different direction from that in which the root is proceeding, in a ſhort time the root turns towards the ſpunge. In this manner the direction of roots may be varied at pleaſure. All plants make the ſtrongeſt efforts, by inclining, turning, and even twiſting their ſtems and branches, to eſcape from darkneſs and ſhade, and to procure the influences of the ſun. Place a wet ſpunge under the leaves of a tree, they ſoon bend downward, and endeavour to apply their inferior ſurfaces to the ſpunge. If a veſſel of water be placed within ſix inches of a growing cucumber, in twenty-four hours the cucumber alters the direction of its branches, bends either to the right or left, and never ſtops till it comes into contact with the water. When a pole is placed at a conſiderable diſtance from an unſupported vine, the branches of which are proceeding in a contrary direction from that of the pole, in a ſhort time, it alters its courſe, and ſtops not till it clings around the pole.

Facts of this kind excite our wonder; but, they by no means prove that vegetables live, or that they are endowed with ſenſation, which implies a diſtinct perception of pleaſure, and pain.

There is an inferior ſpecies of ſenſation, which is diſtinguiſhed by the term *irritability*. This term denotes that power by which muſcular fibres, even after they are detached from the body, contract upon the application of any ſtimulating ſubſtance, whether ſolid or fluid. The heart of a frog, when pricked with the point of a pin, continues to beat, or to contract and dilate, for ſeveral hours after it has been cut out of the animal's body. The heart of a viper, or of a turtle, beats diſtinctly from twenty to thirty hours after the death of theſe animals. The periſtaltic motion of the inteſtines is produced by their irritability. When the inteſtines of a dog, or any other quadruped, are ſuddenly cut into different portions, all theſe portions crawl about like worms, and contract upon the ſlighteſt touch. Though irritability be unqueſtionably a

vital principle, yet it is equally certain, that muſcular fibres, when ſeparated from the body to which they belong, have no diſtinct perception of pleaſure, or pain. Their regular contraction and dilatation are evident ſymptoms of life, which, in many caſes, may lead us to attribute living powers to ſubſtances that enjoy neither life nor ſenſation. Hence, though all plants were irritable, this circumſtance would not prove that they are poſſeſſed of life. The contraction and dilatation of the ſenſitive plants, and the various motions of the leaves, branches, flowers, and roots of vegetables, formerly mentioned, ſeem to indicate that moſt plants are endowed with irritability. Perhaps, all vegetables have more or leſs of this quality. The heart, inteſtines, and diaphragm are the moſt irritable parts of animal bodies: And, to diſcover whether this quality reſides in all plants, experiments ſhould be made chiefly on their leaves, flowers, buds, and the tender fibres of the roots.

From this narration of facts, it appears, that plants make a very near approach to animals; and that this ſimilarity, as well as the difficulty of fixing the preciſe boundaries by which theſe two great kingdoms of nature are limited, are direct conſequences of the organization of vegetables. It is owing to their organic ſtructure alone, that plants and animals are capable of affording reciprocal nouriſhment to each other. This organic ſtructure, though greatly diverſified in the different ſpecies of animals and vegetables, evinces that Nature, in the formation of both, has acted upon the ſame general plan. May we not preſume, therefore, as plants, as well as animals, are compoſed of a regular ſyſtem of organs, that the vegetable part of the creation is not entirely deprived of every quality which we are apt to think peculiar to animated beings? I mean not to inſinuate, that plants can perceive pleaſure or pain. But, as many of their motions and affections cannot be explained upon any principle of mechaniſm, I am inclined to think, that they originate from the power of irritability, which, though it implies not the perception of pleaſure and pain, is the principle that regulates all the vital or involuntary motions of animals. To aſcertain this

this point, would require a ſet of very nice experiments. I ſhall mention one, which might be performed with tolerable eaſe. It was formerly remarked, that plants kept in a hot-houſe, where the degree of heat is uniform, never fail to ſleep during the night. This is direct evidence, that heat alone is not the cauſe of their vigilance. But, they are deprived of light. Let, therefore, a ſtrong artificial light, without increaſing the heat, be thrown upon them. If, notwithſtanding this light, the plants are not rouſed, but continue to ſleep as uſual, then it may be preſumed that their organs, like thoſe of animals, are not only irritable, but require the reparation of ſome invigorating influence which they have loſt while awake, by the agitations of the air and the ſun's rays, by the act of growing, or by ſome other latent cauſe.

It is almoſt unneceſſary to mark the diſtinction between vegetables and minerals. The tranſition from the animal to the plant is effected by ſhades ſo imperceptible, as to elude the moſt acute obſervers. But, between the plant and the mineral, there is a vaſt chaſm in the chain of being, which may be the ſource of great diſcoveries. In bodies purely mineral, not a veſtige of organization can be diſcovered. The fibrous ſtructure of the aſbeſtos has been regarded as an approach toward organization, and as the link which connects the mineral to the vegetable kingdom. But, this is one of thoſe ſtrained analogies which are too often employed by theoretical writers. Though the aſbeſtos is compoſed of a kind of threads, or fibres, theſe fibres are not tubular; neither are they interwoven, like that regular tiſſue, or fabric, which ſo remarkably diſtinguiſhes organized from brute matter. Of courſe, the magnitude of the abeſtos can only be increaſed by the appoſition of new matter, and not by any developement or expanſion of parts. But, though, in the mineral kingdom, Nature ceaſes to organize, ſhe continues to arrange.

The regular configuration of ſalts, chryſtals, and other precious ſtones, has been conſidered, by ſome authors, as the reſult of an organic proceſs. But, the uniform figure of ſalts and chryſtals may be the effect of certain laws of

attraction

attraction peculiar to each ſpecies. None of theſe particles can be regarded as a germ, or bud. They are only the elements, or conſtituent parts, which, when applied to each other, form a whole. They never expand, or grow, like the embrios of animals, or plants. They remain for ever in the ſame ſtate, without diminution, or increaſe, except when ſeparated by force, or magnified by an accumulation of freſh matter. The chryſtalline juice is not aſſimulated by veſſels: It is prepared by a chymical operation of Nature. The bodies of plants and animals are machines, exceedingly elaborate, and more or leſs complicated. Theſe machines, by means of different organs, have the power of converting other animals and vegetables into their own ſubſtance. By this aſſimulation, all their dimenſions are increaſed; and their various parts uniformly preſerve the ſame proportions with regard to each other, and continue to perform their reſpective functions. Beſides, organized bodies not only multiply their ſpecies, but ſome of them poſſeſs the power of reproducing ſuch parts as are forcibly abſtracted from them.

In theſe and many other qualities common to the animal and vegetable, there is not the ſmalleſt analogy to be found in the mineral kingdom. Between the moſt regular foſſils, as ſalts and chryſtals, and the moſt imperfect animal or vegetable, the diſtance is immenſe. Figured foſſils are not more organized than a column, or a portico. In the formation of the former, Nature, in that of the latter, man, is the artiſt. When no ſimilarity is to be diſcovered in thoſe foſſils which are nearly uniform in their configuration, we are not to expect it in the more looſe and irregular parts of brute matter. Here, Nature, regardleſs of ſymmetry, conjoins heterogeneous materials, of which ſhe compoſes irregular maſſes. Many ſtones, flints, and other concretions, afford examples of this kind. More art, it muſt be acknowledged, appears in the formation of metals: But their ſtructure exhibits no veſtiges of organization.

ANALOGIES.

ANALOGIES.

HAVING ſhown the extreme difficulty of fixing the boundaries which ſeparate the animal from the vegetable kingdom, I proceed to the more pleaſing taſk of enumerating ſome of thoſe beautiful analogies which ſubſiſt between them. To render this ſubject the more agreeable and inſtructive, inſtead of bringing together an unconnected maſs, I ſhall trace the analogies between the animal and plant, under the arrangement of *Structure and Organs*, *Growth and Nouriſhment*, *Diſſemination and Decay*.

STRUCTURE AND ORGANS.

IN all organized bodies, a ſimilarity of ſtructure ſeems to be unavoidable. The bodies of men and quadrupeds conſiſt of a ſeries of connected bones, which run from the head to the rump. This ſeries is known by the name of the *back-bone;* from each ſide of which, a number of arched bones proceed. Some of theſe join the breaſt-bone by means of cartilages, and form a vaulted cavity, which contains and defends the heart and other viſcera proper to the cheſt. The bones of the pelvis, and of the four extremities, are joined to the back-bones by articulations, and membranes. By the ſame contrivance, the cranium is fixed to the upper end of the back-bones. Into different proceſſes and portions of all theſe bones, a great number of muſcles, or bundles of fleſhy fibres, are inſerted. Theſe muſcles are the inſtruments which give riſe to all the varieties of animal motion. The bones of the head, or cranium, contain the brain and cerebellum, a prolongation of which runs through the whole extent of the canal in the back-bone, and is known by the term *ſpinal marrow*. From the brain and ſpinal marrow proceed all the nerves, or inſtruments of ſenſation. Theſe nerves,

the ramifications of which are infinitely various, and minute, are diſtributed upon the heart, lungs, blood-veſſels, bowels, and muſcles, till they terminate on the ſkin, or external covering of the body. The heart is the fountain, or general receptacle, of the blood. The contraction of the heart propels the blood through the arteries, which are likewiſe diſtributed, by numerous and complicated ramifications, over every part of the body, and terminate in the veins, which again collect the whole arterial blood into one cavity, and re-convey it to the heart. This circulatory proceſs goes on during life.

Beſide the organs already mentioned, there are others, termed *ſecretory*, becauſe they ſeparate peculiar fluids from the general maſs of circulating blood. The ſtomach and inteſtines are furniſhed with a vaſt number of ſmall tubes, called *lacteal ducts*, which ſeparate and abſorb the nutritious parts of the aliment, and reject all the groſſer and uſeleſs particles. Theſe ducts, after innumerable communications with each other, unite into one large tube, diſtinguiſhed by the name of the *thoracic duct*, which is the general reſervoir of the chyle, or ſecreted liquor. This chyle, which is a mild fluid, paſſes from the thoracic duct to the ſubclavian vein; and by this vein it is conveyed to the heart, where it mingles with the blood, and is circulated through the body, for the nouriſhment of its different parts. It is of no moment, for our preſent purpoſe, to be more particular, eſpecially as this ſubject will be afterwards more fully handled. I ſhall, therefore, juſt mention, that there are particular organs, or glands, for ſecreting various fluids, which are neceſſary to the exiſtence of the larger animals, as the kidneys for the ſecretion of urine; the liver for the ſecretion of gall; the ſtomach for the ſecretion of the gaſtric juices; the ſalivary glands for the ſecretion of ſaliva, &c.

From this ſketch of the ſtructure of man and of quadrupeds, very little attention is neceſſary to perceive, that Nature purſues a ſimilar plan in the formation of birds, and fiſhes.

In that numerous claſs of animals diſtinguiſhed by the name of *inſects*, there is a great variety of form, and ſtructure.

ture. In many of theſe, Nature ſeems to depart from her general mode of operation. But, upon a more accurate examination, this ſeeming departure will appear to be only an extenſion of that univerſal plan which ſhe obſerves in the formation of all animated beings. Some inſects, the lobſter, and all the cruſtaceous and ſhell animals, have their bones on the outſide of their bodies. To theſe bones the muſcles and other inſtruments of motion are attached. Many ſpecies have no bones; but, their bodies conſiſt of a ſucceſſion of rings incaſed into each other. By contracting and dilating theſe rings, all the movements of this kind are performed. The head, in ſome ſpecies, changes its form every moment. It contracts or dilates, appears or diſappears, at the pleaſure of the animal. Theſe motions are permitted by the flexibility of the membranes, or coverings of the head. In other ſpecies, the form of the head is permanent, owing to the hardneſs of the coverings, which are ſcaley, or cruſtaceous, and approaches nearer to that of the more perfect animals.

Many inſects are deſtitute of particular organs. Some want eyes, ears, brain, and noſtrils. Others have an acute ſenſe of ſmelling, though we know not the form or ſituation of the organ. The inferior ſpecies of inſects have no internal lungs, but receive air by lateral pores, and ſometimes by long tubes, or tracheæ, which protrude from different parts of the body. Many inſects have no heart, or general reſervoir for the reception and propulſion of the blood. But, we diſcover by the microſcope, that their blood circulates by the pulſation of arteries, and that their different fluids are ſecreted by glands. In a word, Nature, in the ſtructure and functions of animals, deſcends, by degrees almoſt imperceptible, from man to the polypus; a being which, ever ſince its œconomy and properties were diſcovered by M. Trembley, has continued to aſtoniſh both philoſophers and naturaliſts. The ſtructure of the polypus, which inhabits freſh-water pools and ditches, is extremely ſimple. Its body conſiſts of a ſingle tube, with long *tentacula*, or arms, at one extremity, by which it ſeizes ſmall worms, and conveys them to its mouth. It has no proper head, heart, ſtomach, or inteſtines of any kind.

kind. This ſimplicity of ſtructure gives riſe to an equal ſimplicity in the œconomy and functions of the animal. The polypus, though it has not the diſtinction of ſex, is extremely prolific. When about to multiply, a ſmall protuberance, or bud, appears on the ſurface of its body. This bud gradually ſwells and extends. It includes not a young polypus, but is the real animal in miniature, united to the mother, as a ſucker to the parent-tree. The food taken by the mother paſſes into the young by means of a communicating aperture. When the ſhooting polypus has acquired a certain growth, this aperture gradually cloſes, and the young drops off, to multiply its ſpecies in the ſame manner. As every part of a polypus is capable of ſending off ſhoots, it often happens, that the young, before parting from the mother, begin to ſhoot; and the parent animal carries ſeveral generations on her own body. There is another ſingularity in the hiſtory of the polypus. When cut to pieces in every direction fancy can ſuggeſt, it not only continues to exiſt, but each ſection ſoon becomes an animal of the ſame kind. What is ſtill more ſurpriſing, when inverted as a man inverts the finger of a glove, the polypus ſeems to have ſuffered no material injury; for it ſoon begins to take food, and to perform every other natural function. Here we have a wonderful inſtance of animal ductility. No diviſion, however minute, can deprive theſe worms of life. What infallibly deſtroys other animals, ſerves only, in the polypus, to multiply the number of individuals. M. Trembley, in the courſe of his experiments, diſcovered, that different portions of one polypus could be ingrafted on another. Two tranſverſe ſections brought into contact quickly unite, and form one animal, though each ſection belongs to a different ſpecies. The head of one ſpecies may be ingrafted on the body of another. When a polypus is introduced by the tail into another's body, the two heads unite, and form one individual. Purſuing theſe ſtrange operations, M. Trembley gave ſcope to his fancy, and, by repeatedly ſplitting the head and part of the body, formed hydras more complicated than ever ſtruck the imagination of the moſt romantic fabuliſts.

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This ſhort account of the general ſtructure of animals was a neceſſary preparation for perceiving more clearly their connection with the vegetable kingdom.

The ſtructure of plants, like that of animals, conſiſts of a ſeries of veſſels diſpoſed in a regular order. Theſe veſſels are deſtined to perform the different functions neceſſary to the nouriſhment, growth, and diſſemination of the plant. In trees, and moſt of the larger vegetables, three diſtinct parts are to be obſerved; the bark, the wood, and the pith. The bark likewiſe conſiſts of three parts; the ſkin, the body, and the *liber*, or inner circle; which laſt, about the end of autumn, aſſumes the ſame texture and firmneſs with the wood. The ſubſtance of the bark is compoſed of a number of longitudinal ſap and air veſſels, which have the appearance of fine threads, running from the root to the trunk, and branches. Beſide theſe veſſels, the bark is furniſhed with a parenchymatous or pulpy ſubſtance, in which there is a vaſt variety of *folliculi*, or ſmall bladders. The bark is connected to the wood by tranſverſe inſertions of the parenchyma.

The wood conſiſts of two diſtinct ſubſtances; the one is denſe, and compact, and conſtitutes what is termed the *ligneous body;* the other is porous, moiſt, and pulpy, and is, therefore, called the *parenchymatous* part of the wood. A portion of wood is placed alternately between a ſimilar portion of parenchyma. Theſe alternate portions proceed from the edges of the pith, as *radii* from the center of a circle, widening proportionally as they approach the circumference. Both of them, however, like the bark, are furniſhed with numberleſs ſap and air veſſels.

The pith, or heart, is bounded on all ſides by the wood, and is compoſed of the ſame materials: It is nothing but a vaſt congeries of air and ſap veſſels, interwoven with the parenchyma and bladders, not unlike the tiſſue of gauze, or lace. This texture is common to every part of the trunk, being only more cloſe and compact in the bark and wood than in the pith. It is well known, that the pith of plants diminiſhes in proportion to their age. The reaſon is obvious: Every year the ring of veſ-

ſels, which lies contiguous to the wood, dries, condenſes, and becomes wood.

The leaves of vegetables conſiſt of a fine ſkin, which incloſes the parenchyma, or pulp. This ſkin, like that of animals, is an organic body, furniſhed with an immenſe number of parenchymatous and ligneous fibres, and interwoven in a manner preciſely ſimilar to that of the trunk, and branches. When the ſkin is removed, the pulp appears, and is every where interſperſed with ſmall cylindrical fibres, wound up into minute bladders. A large nerve runs along the middle of every leaf, and continually ſends off branches, which gradually decreaſe in magnitude, till they reach the edge, or diſc. This principal nerve is a collection of ſmall tubes, which, at proper diſtances, go off, and are diſtributed over the leaf in a manner preciſely ſimilar to the diſtribution of the nerves over the human body.

With regard to flowers and fruits, their general texture is the ſame with that of the parts already deſcribed, differing only in various proportions of the ligneous veſſels, and parenchymatous or pulpy ſubſtance. That vegetables are poſſeſſed of ſecretory glands, is apparent from the almoſt infinite variety of their taſtes, odours, and colours. Theſe ſenſible qualities differ even in different parts of the ſame plant. But, the glandular ſecretion of vegetables is moſt conſpicuous in the flowers and fruit. Many flowers ſecrete a nectareous fluid, which is more grateful to the palate than the fineſt honey. The glands of ſome fruits, as thoſe of the lemon and orange, ſecrete liquors of very different qualities. The veſſels of the rhind contain an acrid eſſential oil, while thoſe of the parenchyma, or pulp, ſecrete an agreeable acid.

This ſimilarity in the general ſtructure of animals and plants is ſtrongly corroborated by the analogous parts in both being deſtined to anſwer the ſame purpoſes.

The œconomy and functions of vegetables, as well as thoſe of animals, are the reſults of a vaſcular texture. Each of theſe claſſes of beings have veſſels deſtined to the performance of ſimilar offices. In man and quadrupeds, the fluids are circulated by the pulſation of the heart and arteries.

arteries. The juices of plants do not circulate; but they are raifed from the root to the trunk, branches, leaves, flowers, and fruit, by the fap-veffels. The afcenfion of the fap has been afcribed to capillary attraction. But, though no motion is perceptible in the fap-veffels fimilar to the pulfation of arteries; yet, both the propulfion of the fap, which moves with great force, and the fecretion of different fluids by different parts of the fame plant, imply an action in thefe veffels. In animals, the gall, the urine, the faliva, are all concocted from the general mafs of blood, by the action of particular veffels. Fluids of thefe different qualities exift not in the blood itfelf: They are created by an incomprehenfible operation of the veffels, peculiar to their refpective glands. In plants, the fap afcends, and different fluids are fecreted from it by glandular veffels. Here the fame effects are produced both in the animal and the plant. We muft, therefore, attribute them to the fame caufe, namely, the action of veffels. Befides, the fap, which is the blood of plants, moves with a force often equivalent to the weight of the atmofphere. M. Bonnet remarks *, that he has feen, by means of coloured liquors, the vegetable fap move three inches in an hour; and Dr. Hales, in his Statics, has fhown, that the leaves are the principal organs of tranfpiration. He likewife confiders them to be the inftruments which raife the fap. But, it has fince been difcovered, that coloured liquors rife equally high in branches deprived of leaves, and that they do not rife at all in dried plants. Hence, the fap of vegetables is not taken up in the fame manner as a fpunge imbibes water, but is forced to afcend by an unknown action of the veffels. The fpring of the tracheæ may put in motion the air they contain, and that air may have fome influence on the general movement. But, by whatever powers the fap is moved, the exiftence of the motion is certain; and it is equally certain, that this movement of the fap produces the fame effects in the vegetable, that the force of the heart and arteries does in the animal.

The motion of the fap, in vegetables, is not properly a cir-

* Oeuvres, tom. 1. p. 140. S.

a circulation ſimilar to that of the blood in the more perfect animals. It aſcends and deſcends in the ſame veſſels; and theſe motions are evidently affected by heat and cold. The ſap riſes copiouſly in a warm day, and deſcends during the night, nearly in the ſame manner as the mercury riſes and falls in the thermometer. But, though the analogy here fails with regard to man and the larger animals, yet it holds in the taenia, the polypus, and many other inſects, which exhibit not the ſmalleſt veſtiges of circulation in their juices.

The pith, or medullary ſubſtance of plants, has ſome reſemblance to the brain and ſpinal-marrow of animals. When the texture of the brain or ſpinal-marrow is deſtroyed, life is extinguiſhed; and, when the pith of plants is deſtroyed, or dried up by age, they no longer retain the power of vegetating. The leaves of plants are analogous to the lungs of animals. It is by the lungs that the perſpiration of animals is chiefly effected; and plants diſcharge moſt of their ſuperfluous moiſture by the leaves. They expoſe a large ſurface to the action of the ſun, which produces a tranſpiration ſo copious, that ſome plants throw out fifteen or twenty times more in a given period, than is diſcharged from the human body. When a plant is deprived of its leaves in ſummer, inſtead of ripening its fruit, it is in great danger of dying for want of thoſe organs which carry off the ſuperfluous juices that ariſe from the root. A plant, in this ſituation, may be conſidered as labouring under an aſthma, or dying of a ſuffocation.

Beſide the leaves, plants tranſpire by the pores of the ſkin. But, the quantity emitted in this manner is not nearly equal to that which iſſues from the leaves. The ſame thing happens with regard to man and quadrupeds. Though they likewiſe perſpire through the ſkin, yet by much the greater quantity of perſpirable matter is diſcharged by the lungs. Beſide throwing out ſuperfluous or noxious matter by the leaves, plants, by the ſame organs, abſorb from the atmoſphere, and perhaps from the ſun's rays, ſome unknown matter, which is neceſſary to their exiſtence. The lungs of animals likewiſe derive,

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from the ſame ſources, a particular matter, or principle, without which life could not long be continued.

Another analogy between the ſtructure of plants and animals merits obſervation. The round bones of animals conſiſt of concentric ſtrata, or plates, which can be eaſily ſeparated; and the wood of plants conſiſts of concentric layers of hardened veſſels, which ſeparate when macerated in water. A tree acquires an additional ring every year; and, by counting theſe rings, a pretty exact eſtimation of its age may be attained.

The branches of plants have been conſidered as analogous to the arms or tentacula of animals. But, this is one of thoſe ſtrained analogies which ſhould be carefully avoided. The great uſe of branches is evident. By producing an amazing number of leaves, a large ſurface is expoſed to the air and ſun, to anſwer the important purpoſes of tranſpiration and abſorption. If there is any thing in plants analogous to the arms or tentacula of animals, it muſt be confined to ſuch ſpecies as twiſt themſelves around poles or trees, as the ivy *, the vine †, the convolvulus, &c. and to ſuch as ſupport their trunks on other bodies by means of little hooks, as the gooſe-graſs ‖, and many other kinds.

All theſe analogies, it may be remarked, are confined to large animals, and large vegetables; but they hold not in that numerous tribe of plants called *graſſes*. Inſtead of being filled with wood and pith, their ſtems are perfectly hollow; and, to fortify theſe plants, Nature has beſtowed on them ſtrong joints, or knots, which are placed at regular diſtances in each ſpecies. But, though ſome of the analogies which ſubſiſt between the larger animals and vegetables exiſt not in the ſmaller plants, this circumſtance, inſtead of infringing, confirms the general plan of Nature. To diſcover the analogies between tubular plants and animals, we muſt examine the ſtructure of the minuter tribes of animated beings. The graſſes have neither pith nor wood internally; and the polypus, the taenia, and many other inſects, have no bones, heart, or inteſtines, but are ſimple tubes, perfectly reſembling the empty ſtems of the gramineous

* Hedera. † Vitis. ‖ Galium *Aparine*.

gramineous plants. Beſides, the ligneous, or at leaſt the herbaceous part of theſe plants, is placed on the outſide, ſimilar to the cruſtaceous and ſhell animals, whoſe bones are ſituated externally. Another analogy muſt not be omitted. The ſucculent vegetables, ſuch as the houſe-leek *, the muſhroom tribes, and many ſea-plants, conſiſt almoſt entirely of a pulpy or parenchymatous ſubſtance, and may be cruſhed to a jelly by the ſlighteſt preſſure. The texture of worms, caterpillars, and of all the ſoft inſects, is extremely ſimilar to that of the ſucculent vegetables.

II.—GROWTH AND NOURISHMENT.

THE ſecond ſource of analogies between the plant and animal is derived from the modes of their growth and nouriſhment.

Many ingenious theories have been invented, with a view to explain the myſterious operation by which the growth and nouriſhment of animals and vegetables are effected. But, I ſhall confine myſelf, at preſent, to ſuch remarks as are purely analogical, and may be fully underſtood without a minute knowledge of the different ways by which growth and nouriſhment have been ſuppoſed to be accompliſhed.

Animals, like vegetables, gradually expand from an embryo or gelatinous ſtate, and, according to their kinds, arrive ſooner or later at perfection. This expanſion and augmentation of ſubſtance is the idea conveyed by the word *growth*. Without ſome nutritious matter taken into the body, and aſſimilated, by the action of veſſels, to the ſubſtance of the being that receives it, growth cannot take place. Moiſture is the chief food of plants. But, the food of animals, in general, varies with the ſpecies. This fact led ſome philoſophers to conclude, that every plant extracted from the ſoil a food peculiar to its own nature. It was, however, afterwards diſcovered, by repeated experiments, that vegetables can grow, and acquire

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* Sempervivum *tectorum*, &c.

a very confiderable degree of bulk and weight, without exhaufting a perceptible quantity of the earth in which they are planted. Thefe experiments are a fufficient proof, that moifture conftitutes the chief nourifhment of plants. They likewife indicate, that vegetables, however diverfified in their figure, denfity, and fibrous arrangement, are more fimple in their texture than animals. But, notwithftanding thefe feeming differences in the nourifhment of plants and animals, Nature fails not to obferve the fame courfe in both kingdoms. The food of the animal, before it is converted into nourifhment, muft go through the intricate procefs of digeftion. But, after the food has been converted into chyle, and the chyle into blood, this blood becomes a common fluid, from which all nourifhment and all animal fluids are derived. Here the analogy is apparent. Moifture is to the plant precifely what blood is to the animal. Each of them extracts its nourifhment from a common fluid; and, in both, this fluid is changed, by the action of veffels, into the various juices peculiar to the different fpecies.

When growth firft commences, the embryos of plants and animals are in fimilar circumftances. Soon after conception, the fœtus is inclofed in its membranes, and is nourifhed, till mature for birth, by blood which it receives from the uterus, and placenta. In the fame manner, the embryo of a plant is inclofed in the membranes of the feed; and its fibrous roots are fpread over the lobes, or pulpy part. After the feed is fown, and vegetation commences, the embryo is nourifhed by moifture, which the lobes abforb from the earth, and convey it to the minute tubes of the feminal root. In many plants, thefe lobes rife above the furface of the ground, in the form of leaves, and continue to nourifh and protect the tender plume, or ftem, till it acquires ftrength fufficient to fupport the affaults of the air, and weather. A plant, in this fituation, may be faid to have two roots; one, the fibres of which are diffufed through the fubftance of the lobes, or feminal leaves, and another attached to the foil.

The nourifhment thus conveyed to vegetables by the feminal leaves, is extremely analogous to that of animals

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by the milk of the mother. The texture of young animals is ſo lax and unelaſtic, that the food ſuited to maturer years would ſoon put a period to their exiſtence. But, Nature has provided againſt this inconveniency. She has endowed females with a ſet of veſſels deſtined for the ſecretion of a mild liquor, ſo far concocted and animalized as to be adapted to the tender and flaccid condition of their young. A ſimilar proviſion of nouriſhment is afforded to the young vegetable. For ſome time after the plume and radicle have begun to ſhoot, their texture is ſo extremely tender, that they are unable to ſupport each other without ſome foreign aid. This aid is afforded them by the ſeminal leaves. Theſe leaves abſorb dews, air, and other fine fluids, which are concocted and aſſimilated in the veſſels of the ſeminal root, and then conveyed, in a kind of vegetable form, to the feeble veſſels of the plume. Hence, it is apparent, that the nouriſhing of young animals by milk, and of young vegetables by ſeminal leaves, is the ſame inſtitution of Nature, and effected by ſimilar inſtruments.

Plants, like animals, paſs gradually from an embryo, or infant ſtate, to that of puberty. At this period of their exiſtence, they have acquired that firmneſs of texture, and that evolution of parts, which conſtitute the perfection of their natures, and enable them to produce beings every way ſimilar to themſelves. In both kingdoms, the age of puberty arrives later or more early, according to the difference of ſpecies. Some animals live a few months only. Many of the inſect tribes are produced, grow to maturity, propagate their kind, and die in the courſe of a ſingle ſeaſon. Others, as ſeveral flies, beetles, &c. exiſt two years. Thus animals have a progreſſive duration of life. The dormouſe lives ſix years, the hare ſeven or eight, the bear twenty or twenty-five, the camel forty or fifty, the rhinoceros ſeventy or eighty, the elephant two hundred; and ſome birds and fiſhes are ſuppoſed to exiſt during three or four centuries. The ſame progreſſive duration takes place among vegetables. Some plants are annual, as moſt of the eſculent kinds; others, as the hedge-parſley, the wild-carrot *, the parſnip †, the fox-glove §, the ſcurvy-graſs ‖, &c. are biennial; others exiſt

* Daucus *Carota.* † Paſtinaca *ſativa.* § Digitalis *purpurea.* ‖ Cochlearia.

exiſt three, five, ſeven, ten, twenty, thirty, ſixty, and a hundred years; and the oak *, like the elephant and thoſe birds and fiſhes which are famed for longevity, continues to adorn the foreſt for ſeveral centuries.

The manner by which the nutritious particles are extracted from food, is very ſimilar in the animal and the plant. In the animal, this operation is performed by the lacteal veſſels, which are diſtributed over the internal ſurface of the ſtomach and inteſtines. In the plant, the ſame office is performed by the veſſels of the root and leaves. Hence, animals are organized beings nouriſhed by roots ſituated within their bodies; and plants are organized bodies which abſorb their nouriſhment by roots placed externally. Beſides, in all viviparous animals, the fœtus is nouriſhed, not by food taken in at the mouth, but by veſſels attached to the placenta. Theſe veſſels perform the ſame office to the fœtus, that roots do to vegetables.

Warmth and moiſture are favourable to the production of large and juicy plants; and the animals that feed upon theſe ſucculent and rich vegetables, are likewiſe larger than thoſe which inhabit cold countries, where the plants are ſmaller, more rigid, and contain fewer nutritive particles.

Some plants grow in particular climates only. The *rubus arcticus*, a ſpecies of bramble, ſo common in Norway and Canada, hardly endures the climate of Upſal, in Sweden. But, the *alſine media*, or chickweed, and ſeveral graſſes, are diffuſed over almoſt the whole globe. In the ſame manner, ſome animals, as the camel, the rhinoceros, and the elephant, are produced in warm climates only; while others, as the rein-deer, glutton, and marmot, are confined to the colder regions of the earth; and man, in the animal, like ſome graſſes in the vegetable, kingdom, is univerſal, and inhabits every climate.

Some plants, as well as ſome animals, are amphibious, as the ruſh † and the frog; others are paraſites, and feed on the juices they extract from different ſpecies to which they adhere. The miſſeltoe‖, for example, feeds upon the oak; moſt trees afford nouriſhment to certain moſſes

 and

* Quercus. † Juncus. ‖ Viſcum.

and fungous plants; and every animal is fed upon by ſmaller kinds.

The growth of plants, like that of animals, may be accelerated or retarded by promoting or checking their perſpiration, and by excluding them from proper exerciſe and air. When men, or other animals, are confined to ſituations which prevent the free acceſs of pure air, their growth is retarded; and their ſickly colour indicates a defect of vigour. Plants, when placed in ſimilar circumſtances, are always weak, dwarfiſh, and unnaturally coloured. But exerciſe is equally neceſſary to the health and vigour of plants, as it is to thoſe of animals. The exerciſe of animals is effected by various kinds of ſpontaneous motion. Plants are likewiſe exerciſed by motion; but that motion is not voluntary: It is communicated to them by the action of the air. The agitation which they receive from the winds enables them to extend their roots, prevents them from a growth too rapid, and, of courſe, ſtrengthens their whole fabric. It is owing to the want of this agitation, that plants brought up in houſes, or in other confined ſituations, ſhoot out to an unnatural length; that their ſtems and branches are always ſlender and weak; and that they ripen not their fruit like thoſe which are expoſed to the open air.

To conclude this branch of the ſubject, plants and animals are ſo nearly allied, that their growth and nouriſhment are not only effected by ſimilar inſtruments, but ſome parts of animal bodies evidently partake of a vegetable nature. Thus, the hairs, the nails, the beaks, and the horns, are a ſpecies of vegetables, as appears from their comparative total inſenſibility, as well as from the mode of their growth and reproduction.

III.—DISSEMINATION AND DECAY.

WE ſhall, next, take an analogical view of the diſſemination and decay of the animal and vegetable.

The power of reproduction is peculiar to the plant and animal. Each of them is capable of producing beings every way ſimilar to the parent. But the modes by which this ſingular effect is accompliſhed, are very different in appearance. It is our preſent purpoſe to remove this apparent difference, and to ſhew that animals and vegetables multiply their ſpecies in a manner extremely analogous.

Animals have long been divided into viviparous, and oviparous. The one claſs produce their young alive, the other lay eggs, which muſt be hatched either by the heat of the ſun, or by that of the mother. This diviſion, though very comprehenſive, is not perfect. Several animals have lately been diſcovered which are neither viviparous nor oviparous; and there are animals which unite both theſe modes of multiplication.

The viviparous claſs comprehends men, quadrupeds, and ſome fiſhes, reptiles, and inſects. The oviparous includes birds, ſome reptiles, and moſt of the inſect tribes. But, the armed polypus, or *hydra* of Linnæus, inſtead of being either viviparous or oviparous, multiplies its ſpecies, as formerly remarked, by ſending off ſhoots from the body of the parent.

Another ſpecies, called the *bell-polypus*, or *hydra ſtentorea* of Linnæus, multiplies by ſplitting longitudinally. In twenty-four hours, theſe diviſions, which adhere to a common pedicle, re-ſplit, and form four diſtinct animals. Theſe four, in an equal time, again ſplit; and thus they proceed doubling their numbers daily, till they acquire a figure ſomewhat reſembling a noſegay. The young afterwards ſeparate from the parent ſtock, attach themſelves to the roots or leaves of aquatic plants, and each individual gives riſe to a new colony.

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The funnel-ſhaped polypus multiplies by ſplitting tranſverſely. Of the individuals, accordingly, which proceed from this diviſion, one has the old head and a new tail, and the other a new head and the old tail. The ſuperior diviſion ſwims off, and fixes itſelf to ſome other ſubſtance; but the inferior diviſion remains attached to the former pedicle.

The dart-millepes affords another example of multiplication by ſpontaneous ſeparation. This inſect divides, about two-thirds below the head, into two diſtinct and perfect animals; and it ſeems to poſſeſs no other mode of continuing the ſpecies.

The multiplication of the various animalcules which appear in infuſions of animal and vegetable ſubſtances, long occupied the attention, and eluded the reſearches of philoſophers. This diſcovery of the increaſe of ſome larger animals by ſpontaneous diviſion, gave riſe to the conjecture, that theſe microſcopic animalcules might multiply their numbers in a ſimilar manner. This conjecture was communicated to M. de Sauſſure in a letter from Bonnet, who received an anſwer, dated at Genoa, September 28, 1769, to the following purpoſe.

'What you propoſe as a doubt,' ſays M. de Sauſſure, 'I have verified by inconteſtible experiments, namely, 'that infuſion-animalcules multiply by continued diviſi-'ons and ſubdiviſions. Thoſe roundiſh or oval animal-'cules that have no beak, or hook, on the fore part of 'their bodies, divide tranſverſely. A kind of ſtricture, 'or ſtrangulation, begins about the middle of the body, 'which gradually increaſes, till the two parts adhere by a 'ſmall thread only. Then both parts make repeated ef-'forts, till the diviſion is completed. For ſome time after 'ſeparation, the two animals remain in a ſeemingly torpid 'ſtate. They afterwards begin to ſwim about briſkly. 'Each part is only one half the ſize of the whole: But, 'they ſoon acquire the magnitude peculiar to the ſpecies, 'and multiply by ſimilar diviſions.'——'To obviate every 'doubt,' continues our author, 'I put a ſingle animal-'cule into a drop of water, which ſplit before my eyes. 'Next day. I had five, the day after, ſixty, and, on the

'third

'third day, their number was ſo great, that it was impoſ-
'ſible to count them *.

'Another ſpecies, with a beak, or horn, on the fore 'part of its body, which I obtained from an infuſion of 'hemp-ſeed, multiplied likewiſe by diviſion, but in a man- 'ner ſtill more ſingular than the former. This animal- 'cule, when about to divide, attaches itſelf to the bottom 'of the infuſion, contracts its body, which is naturally 'oblong, into a ſpherical form, ſo that the beak entirely 'diſappears. It then begins to move briſkly round, ſome- 'times from right to left, and ſometimes from left to right, 'the centre of motion being always fixed. Towards the 'end, its motion accelerates, and, inſtead of a uniform 'ſphere, two croſs-like diviſions begin to appear. Soon 'after, the creature is greatly agitated, and ſplits into four 'animalcules perfectly ſimilar, though ſmaller than that 'from which they were produced. Theſe four increaſe 'to the uſual ſize, and each, in its turn, ſubdivides into 'other four †,' &c.

The beauties of Nature have been juſtly celebrated in the uniformity of her productions. This uniformity was early remarked, and gave riſe to the ancient diviſion of animals into viviparous and oviparous, which continued to be adopted, as an univerſal maxim, till within theſe hundred years. Before this period, it was believed by philoſophers, that all animals were either brought forth alive, or hatched from eggs. Among the ancients, indeed, and even down to the time of the celebrated Redi, this maxim included chiefly the more perfect animals; for, with regard to moſt of the inſect tribes, they imagined that theſe were produced by putrefaction, and the admixture of particular kinds of matter. But, Redi, by a ſeries of unqueſtionable experiments, exploded the doctrine of the equivocal generation of inſects; and then the maxim, without farther inveſtigation, was extended to the whole animal kingdom. Redi's experiments and remarks turned the attention of philoſophers to the minuter tribes of animals. In the courſe of a few years, accordingly, ſeveral eminent men aroſe.

* La Palingeneſie Philoſophique, par C. Bonnet, tom. 1. p. 428, 429. S.
† Idem, p. 430. S.

arofe. Reaumur, Bonnet, Trembley, Ellis, Spallanzani, and a multitude of other writers, opened new views with regard to the manners and œconomy of animated beings. M. Bonnet has furnifhed inconteftible evidence, that feveral fpecies of the puceron, or vine-fretter, are both oviparous and viviparous *. In fummer, thefe infects bring forth their young alive; but, in autumn, they depofit eggs upon the bark and branches of trees. Here, the intention of Nature is apparent. The puceron is unable to furvive the winter colds; and, therefore, though viviparous during the warm months, the fpecies could not be continued without this wife provifion. The puceron, it fhould appear, is naturally difpofed to produce live young. The fœtus is inclofed in a membrane, which, like that of the larger animals, burfts before exclufion. But, when the cold feafon commences, the general texture of the animals, as well as of the membranes inclofing the fœtus, becomes more firm and tenacious; and this, perhaps, is the phyfical reafon why they are viviparous in fummer, and oviparous in autumn. Many other flies are known to be viviparous. Upon farther examination, all thefe will probably be difcovered to be alfo oviparous †.

The puceron exhibits another phænomenon ftill more fingular. The maxim, that multiplication prefuppofed impregnation by fexual embraces, was formerly thought to be univerfal. Neither fhould the reception of this maxim be regarded as a matter of wonder; for it was founded on a very general and ftrong analogy. But, the following facts fhow, that Nature, though uniform in many fteps of her progrefs, is not invariably limited to the fame mode of operation.

On the 20th day of May, M. Bonnet took a young puceron, the moment after dropping from the womb of its mother, and fhut it up in a glafs veffel, to prevent all poffibility of communication with any individual of the fpecies. A fprig of the tree on which the animal was produced, fupplied it with nourifhment. The creature changed its fkin four times, namely, on the 23d, 26th, 29th,

* Traité d'Infectologie, par C. Bonnet, tom. 1. p. 194—202. S.
† See Reaumur, tom. 8. edit. 12mo, p. 153. *et feq.* S.

29th, and 31ſt days of the ſame month. After a minute detail of circumſtances, M. Bonnet informs us, that his impriſoned puceron grew with rapidity; that, on the 1ſt day of June, it brought forth; and that, from this day to the 21ſt, it produced no leſs than 95 young, all full of life and vigour *. He frequently repeated this experiment, and it was always followed with the ſame event.

M. Bonnet, ſuſpecting that a ſingle impregnation might influence both the mother and her immediate offspring, reſolved to obviate every difficulty. For this purpoſe, he confined, in ſeparate glaſſes, the young of ſucceſſive births, as they dropped from their mothers. Each of theſe, however, were equally fertile, though he continued the experiment to the ninth generation from the original parent †.

Facts of this kind, which ſeem to interrupt the ordinary current of Nature, ſhould inſpire philoſophers with caution. They ſhould create reverence for ſuch of her operations as are already known; but, they ſhould likewiſe check that raſh ſpirit which too frequently draws unlimited concluſions, before the ſubject be fully inveſtigated. Of all inductions regarding the hiſtory of Nature, the neceſſity of ſexual commerce for multiplying the ſpecies appeared to be the moſt general and the moſt legitimate. The œconomy of the puceron, however, demonſtrates, that even this law is not indiſpenſable, and that Nature has the power of changing her ſteps, and of accompliſhing the ſame purpoſes by various means.

Having enumerated the different modes by which animals multiply their ſpecies, I ſhall next ſhow, that the multiplication of vegetables is extremely analogous.

The viviparous, as well as the oviparous animals, are ſuppoſed to proceed from eggs, with this difference, that the young of the viviparous are hatched in the uterus previous to their excluſion.

Many ſtriking analogies ſubſiſt between the eggs of animals and the ſeeds of plants. When placed in proper circumſtances, they both produce young every way ſimilar

* Bonnet, Traitè d'Inſectologie, tom. 1. p. 39.; and Reaumur. tom. 12. p. 353. S.

† Idem, tom. 1. p. 74. *et ſeq.* S.

lar to the parents. To accomplifh this wonderful effect, the egg requires impregnation, and heat. Moifture, warmth, and foil, or fome fimilar matrix, are neceffary for the exclufion of the young plant. This analogy has been extended much farther by Linnæus, and other fupporters of the fexual fyftem of plants. They maintain, that impregnation is equally indifpenfable to the vegetation of the feed, as to the fertility of the egg. But, as this doctrine will be difcuffed when we come to treat of fexes in general, we fhall here difmifs it without farther remark.

Eggs are not only analogous to feeds, in their general deftination of reproducing individuals, and continuing the fpecies, but there is a great fimilarity in the ftructure and ufes of their refpective organs.

The internal parts of the egg are covered with a cruft, or fhell, and two membranes. Befide thefe, the yoke is included in a feparate membrane. When the two firft membranes are removed, the white appears every way invefting the yoke. In the white, or rather on the membrane of the yoke, a fmall cicatrice is difcernible, in the centre of which is the *punctum faliens*, or embryo of the future animal. After two or three days incubation, this *punctum faliens* becomes red, and fhoots out blood-veffels, which are difperfed through the yoke, in the fame manner as the veffels of a fœtus are diftributed over the placenta.

A feed is likewife covered with a fhell, or cruftaceous membrane. Another membrane invefts the whole kernel, or pulpy lobes of the feed. Each lobe, like the yoke of the egg, is involved in a feparate membrane. In every feed there is alfo a fmall cicatrice, or aperture, through which the young plant iffues. Immediately under this cicatrice, the plume, or future plant, is difcernible, refembling the *punctum faliens* of the egg. The branches of the radicle proceed from this plume, and are difperfed through the fubftance of the lobes, in the fame manner as the blood-veffels iffue from the *punctum faliens* of the egg, and are diftributed over the yoke. It is by the pulp of the lobes that the radicle and plume are nourifhed, till the one fhoots down

into

into the ſoil, and the other mounts above the ſurface. In ſeeds, there is nothing analogous to the white of an egg. Such a proviſion would have been ſuperfluous; for the earth, in which the ſeeds are to germinate, muſt always be moiſt, otherwiſe the young plant could not receive nouriſhment, after iſſuing from the ſeed. Beſides, the eggs of fiſhes have no white, becauſe they are perpetually moiſtened with water.

The analogies ariſing from the multiplication of animals and plants, by means of eggs and ſeeds, are the moſt common, and the moſt obvious. Eggs and ſeeds are evidently organs formed on the ſame plan, and deſtined by Nature to anſwer the ſame general intention: But the multiplication of plants, as well as that of animals, is not confined ſolely to one mode.

The young of viviparous animals, though they probably originate from ſmall eggs, are not brought forth till they have acquired a certain age and firmneſs of texture. It may be thought, that there is no multiplication of plants which has any reſemblance to that of viviparous animals. We ſhould reflect, however, that plants can multiply by buds. Now, a bud has no analogy, either in texture or appearance, to a ſeed. Buds ariſe from the ſtems or branches of vegetables. One object in their formation is to produce leaves and branches, as well as to extend the length of the trunk or ſtem. But, they are likewiſe endowed with the faculty of reproducing new individuals. In this reſpect, trees and ſhrubs may be conſidered as viviparous plants; becauſe they produce out of their own bodies an organ, which, though differing in every view from a ſeed, is brought forth alive, and, when properly cheriſhed, is converted into a being perfectly ſimilar to the parent, and capable of continuing its ſpecies. The embryo of a bud commences its exiſtence under the bark. Here it remains, for ſome time, incloſed in membranous coverings, and attached to the bark by minute fibres, which convey to it a nouriſhment ſuited to its condition. When arrived at a certain ſize and conſiſtence, it pierces the bark, and ſhoots out into the open air. If allowed to remain on the parent, it ſoon burſts through its mem-

 branes,

branch, and, in time, gives riſe to a new branch: But, when detached from the parent, and placed in proper circumſtances, it becomes a new individual of the ſame ſpecies.

Bulbous-rooted plants furniſh a ſtill ſtronger analogy between the increaſe of viviparous animals and that of vegetables. In the end of autumn, if the coats of any bulbous root be carefully diſſected, the entire plant in miniature will appear in the centre of the root *. In ſpring, this ſmall plant, like a fœtus incloſed in the uterus, pierces the coats of which the root conſiſts, and gradually grows till it flowers, ripens its ſeeds, and dies at the approach of winter, when a new plant is again formed in the old root. Here we have an example of the multiplication of plants ſimilar to that of the puceron; but the order of time is reverſed. The puceron is viviparous in ſummer, and oviparous in autumn; but, bulbous-rooted plants may be conſidered as oviparous in ſummer, and viviparous in autumn.

The ſame analogy is to be traced in thoſe roots which have what are called *eyes*, like the potato. Theſe eyes are all plants in miniature, which live in that ſtate during the winter, and, when committed to the ſoil, come to maturity in ſummer.

There are ſtill other modes of multiplying common to the animal and vegetable. Many plants are multiplied by ſuckers, ſlips, and cuttings.

The animal kingdom furniſhes examples of all theſe modes of multiplication. The ſuckers of plants have an exact analogy to the ſhoots of a polypus. When ſeparated from the parent, the ſucker bncomes a perfect plant, and the ſhoot of the polypus a perfect animal. Plants are capable of multiplication by ſlips and cuttings: And the portions of a polypus, however ſmall, or when cut in any direction, reproduce, and become perfect animals of the ſame ſpecies.

But, ſome ſpecies of the polypus, the dart-millepes, and ſeveral animalcules which appear in infuſions of animal and

* M. Mariotte and many other writers, have ſeen in the bulb of the tulip, not only the leaves, but even the flowers, and the ſtamina.

and vegetable ſubſtances, multiply by ſplitting, or ſpontaneous ſeparation. Here the analogy between the animal and vegetable might be ſuppoſed to fail. The water-lentil, however, a ſmall plant, which covers the ſurface of ſtagnating pools, multiplies its ſpecies by detaching thin films from the under ſide of the leaf. Theſe films, or tender leaves, produce roots, and vegetate into a regular plant.

We muſt not diſmiſs this ſubject till another analogy be unfolded. All animals have ſeaſons peculiar to their reſpective kinds. Some of the larger animals produce in the ſpring, others in ſummer, others in autumn, and others in winter. With regard to the inſect tribes, their ſeaſons are ſtill more various. Every month, every week of the year, gives birth to different ſpecies. The ſeaſons of plants are diverſified in a ſimilar manner. The growth of different vegetables is diſtributed over the whole year. Particular tribes ſpring up at the ſame uniform periods. In this beautiful diverſity of arrangement, the intentions of Nature are evident. If all plants were to ruſh forward at the ſame time, they would infallibly choke each other. The ſurface of the earth could not afford them room. Nature has, therefore, wiſely ordained, that the earth ſhould always be covered with plants: But, ſhe has alſo ordained, that particular tribes ſhould die at ſtated periods, to make way for the exiſtence of others. The ſame inconvenience would happen, if the production of all animals, and particularly that vaſt number of ſpecies, and that immenſe profuſion of individuals, to which the inſect tribes give birth, were to take place at one period. The air would be ſo crowded with noxious creatures, that neither man nor the larger animals could poſſibly exiſt. Beſides, the ſpecies which feed upon particular plants, if they were produced at a time when theſe plants did not flouriſh, would infallibly periſh for want of food. In Lapland, where the duration of heat is extremely ſhort, the whole inſects, which inhabit that dreary and barren region, are produced in a few weeks. Though the number of ſpecies, compared with that of the more prolific climates, be very limited, the inconvenience is ſeverely felt. But,

every natural evil is accompanied with ſome advantage. The rein-deer, upon which the exiſtence of the Laplanders chiefly depends, are tormented by the ſwarms of flies. To avoid their numberleſs enemies, theſe animals leave the vallies, and aſcend the mountains, where the cold is too great for the flies to follow. In theſe lofty regions, the rein-deer feed during the hot ſeaſon, and return to the vallies after the cold has deſtroyed the myriads of inſects. This forced migration has two good effects: It both preſerves the health of the rein-deer, and the vegetables in the vallies, which otherwiſe would have been prematurely exhauſted.

The operation of engrafting was long thought to be peculiar to the vegetable kingdom. But, M. Trembley found, that ſeveral ſpecies of the freſh-water polypus could ſucceſsfully undergo this wonderful proceſs. Since his time, it has been diſcovered, that the *actinia*, or ſea-nettle, is likewiſe capable of being engrafted to an individual of the ſame or of a different ſpecies. In all theſe inſtances, the portions of the divided animals grow together, and become diſtinct individuals.

Having traced the general analogies between the ſtructure and œconomy of the animal and vegetable, from the rudiments of their exiſtence till they have acquired full maturity, and performed the neceſſary office of multiplying their ſpecies, we proceed to the laſt and only melancholy branch of this ſubject, the unavoidable decay and death of every ſucceſſive individual in both kingdoms.

It is an invariable law of Nature, that all organized bodies ſhould have a conſtant tendency to diſſolution. But, the periods of their exiſtence vary according to the ſpecies. Previous to actual reſolution, plants as well as animals are ſubject to a number of analogous affections and diſeaſes. When over-heated, plants ſhow evident marks of languor and fatigue: Their leaves become flaccid, their ſtems and branches bend toward the earth, their juices evaporate, and their whole texture aſſumes the appearances of weakneſs and decay. The application of too great a degree of cold makes the flowers, the leaves,

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the bark, and even the woody fibres, ſhrivel and contract in their dimenſions. When deprived of proper light and air, their colours fade, and they ſoon acquire a lurid and ſickly aſpect. They are likewiſe ſubject to be ſtarved for want of nouriſhment. The growth of plants, as well as that of animals, is checked by ſcanty ſupplies of food. When the ſoil or ſituation is unkindly, vegetables are always weak and dwarfiſh, and their prolific powers are diminiſhed. They may alſo be poiſoned by the abſorption of fluids hoſtile to their conſtitution. Beſide theſe general affections, common to the plant and animal, vegetables are injured, and often killed, by particular diſeaſes.

Some diſeaſes attack the leaves only, and produce ſpots of various colours, rugoſities, puſtules, galls, &c. Others are peculiar to the flowers and fruit, and often occaſion barrenneſs for a ſeaſon; and ſometimes this ſterility continues during the exiſtence of the plant. Others aſſault the viſcera, or internal organs, and give riſe to obſtructions, tumors, and a gradual reſolution and corruption of the whole fabrick. Many of the diſeaſes of plants are produced by the inſect tribes. Their wounds and depredations are not confined to particular parts, but extend from the root to the ſtem, branches, leaves, flowers, and fruit. Inſects not only injure the ſubſtance of plants, but, by feeding on their juices, deprive them of a part of their nouriſhment, and occaſion various diſeaſes or changes in their organization. Other diſeaſes of plants derive their origin from change of climate, from miaſmata or noxious vapours in the atmoſphere, and from improper culture. When wounded by external injuries, vegetables diſcharge their blood in copious ſtreams. If the wound be not mortal, the fibres on all ſides gradually ſhoot out, and cloſe the fracture by a callous ſubſtance.

From this general enumeration, it is obvious, that the diſeaſes of plants are not only ſimilar to thoſe of animals, but proceed from the ſame cauſes. In both kingdoms, ſome diſeaſes are only partial or ſuperficial, and are cured either by Nature, or by the aſſiſtance of art. Others are mortal, and ſucceeded by a total putrefaction or decompoſition of the individual.

But,

But, though plants ſhould eſcape the numberleſs diſeaſes which daily threaten them, they have no defence againſt the ſlower approaches of old age, and its unavoidable conſequence, death. In progreſs of time, the veſſels gradually harden and loſe their tone. The juices no longer move with equal celerity as in youth. They are not abſorbed with the ſame preciſion. They at laſt ſtagnate, and corrupt. This corruption is ſoon communicated to the veſſels in which the juices are contained, and produces a total ceſſation of all the vital functions.

The life of animals is diverſified by a number of ſucceſſive changes. Infancy, youth, manhood, old age, are characteriſed by imbecility, beauty, fertility, dotage. All theſe viciſſitudes are conſpicuous in the vegetable world. Weak and tender in infancy, beautiful and vigorous in youth, robuſt and fruitful in manhood, and, when old age approaches, the head droops, the ſprings of life dry up, and the tottering vegetable, like the animal, returns to that duſt from which it ſprung.

Upon the whole; by taking a retroſpective view of the extreme difficulty of aſcertaining the boundaries which diſtinguiſh the animal from the vegetable, and of the ſimilarities in their ſtructure and organs, in their growth and nouriſhment, in their diſſemination and decay, it is apparent, that both theſe kingdoms conſtitute the ſame order of beings, and that Nature, in the formation of them, has operated upon one great and common model *.

CHAP.

* The numerous attempts which have made by naturaliſts to define the boundaries which terminate the chain of animals, and to explain the nature and attributes of the vegetable ſeries, conſidered as a claſs, or order, of living beings eſſentially differing from animals, have, hitherto, as our author has obſerved, proved "abortive." Even in the preſent improved ſtate of *Natural Knowledge*; in an age of which philoſophy and wiſdom, next to the love of freedom, are the moſt prominent and diſtinctive features, our labours have not been able to conduct us to an acquaintance with any marks, or characters, which decidedly diſtinguiſh the world of animals and vegetables. A late writer, however, Dr Hedwig, of Leipſic, who to the knowledge of the *Botaniſt* unites the talents of the *Philoſopher*, is of opinion, that theſe two claſſes of beings are moſt unequivocally diſtinguiſhed from each other by this circumſtance, that the *ſtamina*, or *male organs*, of vegetables periſh immediately after they have performed the important office of fecundation, whilſt the ſame organs in animals ſurvive this function, and, in moſt caſes, are capable of repeating it. I do not doubt the ſolidity of this definition. I mean not to aſſert that animals and vegetables conſtitute but *one great family of beings*. In the eye of *Nature*,

CHAP. II.

Of the organs and general ſtructure of Animals—A ſhort view of the external and internal parts of the human body—This ſtructure compared with thoſe of Quadrupeds, Birds, Fiſhes, and Inſects—How far peculiarities of ſtructure are connected with peculiarities of manners and diſpoſitions.

IN treating of this ſubject, it is not intended to dive into the depths of anatomical reſearch. On the contrary, I ſhall exhibit ſhort views only of the general ſtructure and organization of the various claſſes of animated beings, from man, who is the moſt perfect animal of which we have any knowledge, down to the inſect tribes. Conſidering man, therefore, as the ſtandard of animal perfection, we ſhall inſtitute frequent compariſons, and mark peculiar diſtinctions, between him and the brute creation, both with regard to form, manners, and ſagacity. By following this plan, I hope I ſhall be enabled to render a ſubject which, at firſt ſight, may have a forbidding aſpect, both intereſting and agreeable.

STRUCTURE OF MAN.

THE bones may be regarded as the baſis upon which the human body is conſtructed. The ſpine, or back-bone, conſiſts of a number of vertebræ, or ſmall bones, connected together by cartilages, articulations, and ligaments. In the centre ef each vertebra there is a foramen, or hole, for the lodgement and continuation of the ſpinal marrow, which

Nature, there is, moſt probably, a diſtinction between theſe objects; but this diſtinction *Man* has never been able to define. The diſcovery is, poſſibly, reſerved for ſome happy genius, in an age more enlightened by ſcience.

which extends from the brain to the rump. From theſe vertebræ the arched bones called ribs proceed; and ſeven of them join the breaſt-bone on each ſide, where they terminate in cartilages, and form the cavity of the thorax, or cheſt. This cavity contains the heart and lungs; and the œſophagus, or gullet, paſſes through it to reach the ſtomach. The five lower ribs, with a number of muſcles, form another cavity termed the *abdomen*, or belly, in which are contained the ſtomach, the bowels, the *omentum*, or cawl, the liver, the gall-bladder, the ſpleen, the pancreas, and the kidneys. The cheſt and abdomen are ſeparated from each other by the diaphragm, or midriff. The lower part of this laſt cavity contains the bladder of urine, and the rectum, or termination of the inteſtines. Beſide theſe, in females, the pelvis includes the uterus and its appendages. This part of the cavity is formed by the os ſacrum, or termination of the back-bone, and the two oſſa innonimata.

The bones of the cranium and face are very numerous. They are connected together by means of ſutures, articulations, and membranes. The bones of the cranium include the brain, and its two membranous coverings, called the *pia* and *dura mater*, and the medulla oblongata, of which laſt the ſpinal marrow is a prolongation. The bones of the upper and under jaw form another cavity for the reception of the tongue and organs of ſpeech.

The only remaining bones are thoſe of the upper and lower extremities. The ſhoulder and collar bones articulate with the top of the arm and breaſt-bone. The arm-bone, or *os humeri*, is joined to the two bones of the fore-arm, called *ulna* and *radius*, and theſe laſt to the bones of the *carpus*, or wriſt, by means of articulations and firm membranes. To the bones of the wriſt, thoſe of the metacarpus and fingers are attached in a ſimilar manner.

With regard to the lower extremities, the thigh-bone articulates above with the hip-bone, and below with the leg-bone and the rotula, or knee-pan. The leg, like the fore-arm, is compoſed of two bones, the tibia and fibula, which articulate with each other, and with the tarſal, or

heel-

heel-bones of the foot; and to theſe laſt the metatarſal bones, and thoſe of the toes, are joined.

From this outline, ſome idea may be formed of the human ſkeleton. The other parts of which our bodies are compoſed, ſhall be mentioned in the ſame curiory manner.

The muſcular part of the human fabrick conſiſts of numerous bundles of fleſhy fibres. Each bundle, or diſtinct muſcle, is incloſed in a cellular mem rane, by which means they may be raiſed, or ſeparated from one another, by the hand of the anatomiſt. They are inſerted, by ſtrong tendinous extremities, into the different bones of which the ſkeleton is compoſed, and, by their contraction and diſtenſion, give riſe to all the movements of the body. The muſcles, therefore, may be conſidered as ſo many cords attached to the bones; and Nature has fixed them according to the moſt perfect principles of mechaniſm, ſo as to produce the fitteſt motions in the bones or parts for the movement of which they are intended.

The heart is a hollow muſcular organ, of a conical ſhape, and conſiſts of four diſtinct cavities. The two largeſt are called *ventricles*, and the two ſmalleſt *auricles*. The heart is incloſed in the *pericardium*, a membranous bag, which likewiſe contains a quantity of water, or lymph. This water lubricates the heart, and facilitates all its motions. The heart is the general reſervoir of the blood. By the contractions and dilatations of this muſcle, the blood is alternately thrown out of, and received into, its ſeveral cavities. When the heart contracts, the blood is propelled from the right ventricle into the lungs through the pulmonary arteries, which, like all the other arteries, are furniſhed with valves that play eaſily forward, but admit not the blood to regurgitate toward the heart. The blood, after circulating through the lungs, returns into the left ventricle of the heart by the pulmonary vein. At the ſame inſtant, the left ventricle drives the blood into the aorta, a large artery which ſends off branches to ſupply the head and arms. Another large branch of the aorta deſcends along the inſide of the back-bone, and detaches numerous ramifications to nouriſh the viſcera and inferior

extremities. After ſerving the moſt remote extremities of the body, the arteries are converted into veins, which, in their return toward the heart, gradually unite into larger branches, till the whole terminate in one great trunk called the *vena cava*, which diſcharges itſelf into the right ventricle of the heart, and completes the circulation.

Beſide the heart, the thorax, or cheſt, contains the lungs, or organs of reſpiration. They are divided into five lobes, three of which lie on the right, and two on the left ſide of the thorax. The ſubſtance of the lungs is chiefly compoſed of infinite ramifications of the trachea or windpipe, which, after gradually becoming more and more minute, terminate in little cells, or veſicles, which have a free communication with one another. At each inſpiration, theſe pipes and cells are filled with air, which is again diſcharged by reſpiration. In this manner, a circulation of air, which is neceſſary to the exiſtence of men and other animals, is conſtantly kept up as long as life remains.

The inſtruments and proceſs of digeſtion fall next to be conſidered. The ſtomach is a membranous and muſcular bag, furniſhed with two orifices: By the one it has a communication with the *œſophagus*, or gullet, and by the other with the bowels, which begin at the ſtomach and terminate at the anus. In the ſtomach and inteſtines there are immenſe numbers of minute veſſels called *lacteals*, the mouths of which are conſtantly open for the reception of the nutritious particles. After being moiſtened and lubricated by the ſaliva, the food is received into the ſtomach, where it is ſtill farther diluted by the gaſtric juice, which has the power of diſſolving every kind of animal and vegetable ſubſtance. When the food has remained ſome time in the ſtomach, it is reduced to a greyiſh pulp, mixed with ſome chylous or milky particles. The thinner and more perfectly digeſted parts of the food gradually paſs through the *pylorus*, or lower aperture of the ſtomach, into the inteſtines, where they are ſtill farther attenuated and digeſted by the bile and pancreatic juices. While the food is in this fluid ſtate, it receives the denomination of *chyle*, and is continually abſorbed by the mouths

of

of the lacteal veins. Theſe veſſels ariſe, like net-work, from the inner ſurface of the inteſtines, paſs obliquely through their coats, and, running along the meſentery, unite, as they advance, into larger branches, and at laſt terminate in the thoracic duct, or general receptacle of the chyle. Beſide the lacteals, there is another ſyſtem of veſſels called *lymphatic*, or abſorbent veins*: They are minute pellucid tubes, and generally lie cloſe to the large blood-veſſels. The lymphatics from all the lower parts of the body gradually unite as they approach the thoracic duct, into which they pour a colourleſs fluid by three or four large trunks; and the lymphatics from all the ſuperior parts of the body, likewiſe diſcharge their lymph into the ſame duct, as it runs upward to terminate in the left ſubclavian vein. By this curious and beautiful machinery, the chyle and lymph, which conſiſt of the nutritious matters extracted from the food, enter the circulating ſyſtem, are converted into blood, and afford that conſtant ſupply of nouriſhment which the perpetual waſte of our bodies demands.

We ſhall next give a ſketch of thoſe important organs by which we are enabled to multiply and continue the ſpecies. The circulation of the blood, and the mode by which the quantity of it is continually kept up by freſh ſupplies of chyle, are effects which, in ſome meaſure, correſpond with our ideas of the machinery employed. The organs of generation exhibit a ſtill more complex ſpecimen of exquiſite mechaniſm. But, the machinery employed, without the aid of experience, could never ſuggeſt the moſt diſtant idea of the effect to be produced.

In the male, the organs of generation conſiſt of the teſtes, the ſeminal veſſels, and the penis. The teſtes are two glandular bodies which poſſeſs the power of converting the blood into ſemen. They are originally formed and lodged in the abdomen; and it is not till after birth, that they commonly paſs into the groin, and from thence fall into the ſcrotum, which is a muſcular bag prepared for their reception and defence. The teſtes of the hedge-hog,

* The lacteals and lymphatics, properly ſpeaking, conſtitute the ſame great ſyſtem of veſſels.

hog, and of some other quadrupeds, remain in the abdomen during life. Instances of the same kind sometimes happen in the human species. Each testicle is composed of the spermatic artery and vein. The blood passes very slowly through the spermatic artery, and produces an infinite number of convolutions in the substance of the testicle, where it deposits the semen, which is taken up by the semeniferous tubes. These tubes at length unite, and, by an immense number of circumvolutions, form a kind of appendix to the testicle, commonly known by the term *epididymis*. The tubes of the epidydymis, after terminating in an excretory duct called *vas deferens*, ascend toward the abdominal rings, and deposit the semen in the seminal vesicles, which are two soft convoluted bodies situated between the rectum and bladder, and unite at their lower extremity: From these reservoirs the semen is occasionally discharged through the short canals which open into the urethra. The penis is a cavernous and spungy substance, perforated longitudinally by a canal called the *urethra*, which, by communicating with the bladder and seminal vessels, answers the double purpose of discharging both the urine and semen.

With regard to the female organs, the uterus and its appendages merit a principal attention. The uterus is a hollow muscular body, situated between the rectum and bladder, and, when not in an impregnated state, resembles a pear, with the thickest end turned toward the abdomen. The entrance into the cavity of the uterus forms a small protuberance, which has been compared to the mouth of a tench, and from this circumstance it has received the name of *os tincæ*. The uterus is connected to the sides of the pelvis by two broad ligaments, which support it in the vagina in a pendulous situation. From each side of the bottom of the uturus the two Fallopian tubes arise, pass through the substance of the uterus, and extend along the broad ligaments till they reach the edge of the pelvis; from whence they are reflected backward, and turning over behind the ligaments, their extremities hang loose in the pelvis. These extremities, because they have a ragged

a ragged appearance, are called *ſimbriæ*, or *morſus diaboli*: Each Fallopian tube is about three inches long. Their cavities are at firſt very ſmall, but become gradually larger, like a trumpet, as they approach the fimbriæ. Near the fimbriæ of each tube, about an inch from the uterus, are ſituated the ovaria, or two oval bodies, about half the ſize of the male teſticle. They are covered with a production of the peritoneum, and hang looſe in the pelvis. In their ſubſtance there are ſeveral minute veſicles filled with lymph. The number of theſe veſicles ſeldom exceeds twelve in each ovarium. In mature females, theſe veſicles become exceedingly turgid; and a yellow coagulum gradually forms in one of them, which increaſes till its coat diſappears. It then changes into a hemiſpherical body called *corpus luteum*, which is deſcribed as being hollow and containing within its cavity very minute eggs, each of which, it is ſuppoſed, may be impregnated, and produce a fœtus. After impregnation, one of theſe eggs, as we are informed by anatomiſts, is abſorbed by and paſſes through the Fallopian tube into the uterus, where it is nouriſhed till mature for birth.

We ſhall conclude this ſubject with a conciſe account of the inſtruments of ſenſation. The organs hitherto deſcribed convey nothing more than the idea of an automaton, or ſelf-moving machine. But ſenſation, or the perception of pleaſure and pain, is effected by organs of a peculiar kind. Theſe organs are all comprehended under the general appellations of the *brain* and *nerves*.

Beſide the bones of the cranium, the brain is inveſted with two membranes, called *dura* and *pia mater*, becauſe they were ſuppoſed by the Arabians to be the ſource of all the other membranes of the body. Under the denomination of *brain* are comprehended three diſtinct parts, the *cerebrum*, the *cerebellum*, and *medulla oblongata*. The *cerebrum* is a ſoft medullary maſs, ſituated in the anterior part of the ſkull, and divided, by a portion of the dura mater, into two hemiſpheres. It conſiſts of two ſubſtances, the cortical, which is greyiſh, and the medullary, which is ſofter, and of a very white colour. The *cerebellum* is divided into two lobes, and its ſubſtance is firmer

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and more compact than that of the cerebrum. It is likewise composed of the cortical and medullary ſubſtances. The reunion of the medullary ſubſtances of the cerebrum and cerebellum, at the baſis of the ſkull, forms the *medulla oblongata*, of which the ſpinal marrow is a continuation. The brain of the human ſpecies is proportionally much larger than that of quadrupeds.

The brain and ſpinal marrow are ſuppoſed to be the origin of all the nerves or inſtruments of ſenſation. The nerves are, in general, cineritious, ſhining, inelaſtic cords. But, they differ from each other in ſize, colour, and conſiſtence. From numberleſs experiments and obſervations, it is unqueſtionable, that the nerves are the inſtruments both of ſenſation and of animal motion. But, how theſe effects are produced by the nervous influence, is a diſcovery ſtill to be made. The inquiry, however, has given riſe to ſeveral ingenious conjectures and hypotheſes. Some phyſiologiſts have maintained, that the nerves are ſolid cords, which may be divided into an infinite number of minute filaments; and that, by the vibrations of theſe cords, the various impreſſions and modifications of feeling are conveyed to the brain. Others, with more plauſibility, have ſuppoſed that the nerves are aſſemblages of ſmall tubes; that a ſubtile fluid, ſometimes called *animal ſpirits*, is ſecreted in the brain and ſpinal marrow; and that by the influence or motions of this fluid all the ſenſations of animals are tranſmitted to the ſenſorium, or general repoſitory of ideas. But, it is needleſs to dwell upon a ſubject covered with darkneſs, and which all the efforts of human powers will probably never bring to light.

Anatomiſts have deſcribed forty pair of nerves. Ten of them proceed from the medulla oblongata of the brain, and thirty from the ſpinal marrow. Theſe nerves, by ſending off innumerable ramifications, are diſtributed, like a net-work, over every part of the body, till they terminate, in the form of minute papillæ, upon the ſkin. That the nerves are the immediate inſtruments of ſenſation, as well as of muſcular motion, has been proved by a thouſand uncontrovertible experiments. When the trunk of the ſciatic nerve is cut, the thigh and leg on

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that ſide inſtantly loſe all motion, and all ſenſe of pain, below the inciſion, and neither time nor art can ever reſtore the power of feeling or of moving. But the parts between the inciſion and the ſpinal marrow, which is a continuation of the brain, retain their uſual degrees both of motion and of ſenſation. From this experiment, it is evident, that the nerves are the organs by which ſenſation and motion are effected, and that, for theſe important purpoſes, an uninterrupted connection between any particular nerve and the brain, or ſpinal marrow, is indiſpenſible.

This ſketch of the human fabrick requires an apology to anatomical readers, who muſt be ſenſible of its many imperfections. To perſons who have not ſtudied that curious and uſeful ſcience, I imagined a general view of the ſtructure of man, if properly compoſed, might enable them to acquire more diſtinct ideas of the many ſeeming deviations from the common plan obſerved by Nature in the formation of the inferior and more imperfect animals.

OF THE STRUCTURE OF QUADRUPEDS.

HAVING delineated the ſtructure and organs of the human ſpecies, it is worthy of remark, that the intellect, or ſagacity, of inferior animals augments or diminiſhes in proportion as the formation of their bodies approaches to, or recedes from, that of man. Quadrupeds, accordingly, are more intelligent than birds; the ſagacity of birds exceeds that of fiſhes; and the dexterity and cunning of fiſhes are ſuperior to thoſe of moſt of the inſect tribes. The ſame gradation of mental powers is exhibited in different ſpecies of the ſame claſſes of animals. The form of the orang outang makes the neareſt approach to the human; and the arts he employs for his defence, the actions he performs, and the ſagacity he diſcovers, are ſo aſtoniſhing, that ſome philoſophers have conſidered him as a real human being in the moſt debaſed ſtage of ſociety. Next to the orang outang, the organs of the different

ſpecies

ſpecies of apes and monkeys have the greateſt reſemblance to thoſe of man; and their powers of imitation, their addreſs in procuring their food, and in managing their young, their ingenuity, and their ſagacious manners, have contributed to the amuſement and excited the admiration, of mankind in all ages and nations. The ſame relation between form and intellect may be traced in the dog, the cat, the ſow, the horſe, the ſheep, and the other ſpecies of quadrupeds.

With regard to the general ſtructure and figure of quadrupeds, a great variety is exhibited in the different kinds. But, when examined in detail, it is apparent that they, as well as man, are all formed upon one primitive and general deſign. Beſide the organs of ſenſation, of circulation, of digeſtion, and of generation, without which moſt animals could neither ſubſiſt nor multiply, there is, even among thoſe parts that chiefly contribute to variety in external form, ſuch a wonderful reſemblance as neceſſarily conveys the idea of an original plan upon which the whole has been executed. For example, when the parts conſtituting a horſe are compared with the human frame, inſtead of being ſtruck with their difference, we are aſtoniſhed at their ſingular and almoſt perfect reſemblance. Take the ſkeleton of a man, ſays Buffon, incline the bones of the pelvis; ſhorten thoſe of the thighs, legs, and arms: join the phalanges of the fingers and toes; lengthen the jaws by ſhortening the frontal bones; and, laſtly, extend the ſpine of the back. This ſkeleton would no longer repreſent that of a man: It would be the ſkeleton of a horſe. For, by lengthening the back-bone and the jaws, the number of the vertebræ, ribs, and teeth, would be increaſed; and it is only by the number of theſe bones, and by the prolongation, contraction, and junction of others, that the ſkeleton of a horſe differs from that of a man. The ribs, which are eſſential to the figure of animals, are found equally in man, in quadrupeds, in birds, in fiſhes, and even in the turtle. The foot of the horſe, ſo apparently different from the hand of a man, is compoſed of ſimilar bones; and, at the extremity of each finger, we have the ſame ſmall bone, reſembling the ſhoe

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of a horſe, which bounds the foot of that animal. Raiſe the ſkeletons of quadrupeds, from the ape-kind to the mouſe, upon their hind-legs, and compare them with the ſkeleton of a man, the mind will be inſtantly ſtruck with the uniformity of ſtructure and deſign obſerved in the formation of the whole group. This uniformity is ſo conſtant, and the gradations from one ſpecies to another are ſo imperceptible, that to diſcover the marks of their diſcrimination requires the moſt minute attention. Even the bones of the tail will make but a ſlight impreſſion on the obſerver. The tail is only a prolongation of the *os coccygis*, or rump-bone, which is ſhort in man. The orang-outang, and true apes*, have no tail; and, in the baboons, and ſeveral other quadrupeds, the tail is exceedingly ſhort. Thus, in the creation of animals, the Supreme Being ſeems to have employed only one great idea, and, at the ſame time, to have diverſified it in every poſſible manner, that men might have an opportunity of admiring equally the magnificence of the execution and the ſimplicity of the deſign.

In quadrupeds, as well as in man, the bones are connected by articulations and membranes; and the different movements of theſe bones are performed by the operation of muſcles. The number, diſpoſition, and form of the muſcles, with a few exceptions ariſing from the figure and deſtination of parts peculiar to particular animals, are nearly the ſame in men and in quadrupeds. The circulation of their blood, the ſecretion of their fluids, and the proceſs of digeſtion, are carried on by organs perfectly ſimilar to thoſe of the human body. In the external covering, a ſmall difference takes place. Quadrupeds are furniſhed with a thick covering of hair, or wool, to defend them from the injuries of the weather. Being deſtitute of art ſufficient to make garments, Nature has ſupplied that defect, by giving them a coat of hair, which varies in thickneſs according to the ſeaſon of the year, and the difference of climate. In Ruſſia, Lapland, Kamtſchatka, and all the northern regions, the furs of animals are very thick and warm. But, in Turkey, Africa, and

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* The *Simiæ* of the ancient naturaliſts.

the ſouthern parts of Aſia and America, moſt quadrupeds are thinly clad, and ſome of them, as the Turkiſh dog, are totally deſtitute of hair.

The ſkin of quadrupeds is diſpoſed nearly in the ſame manner as the human, only it is more elaſtic. Immediately under the ſkin, there is a thin muſcular ſubſtance, called *panniculus carnoſus*, which is common to all quadrupeds, except the hog and armadillo* kinds. This ſubſtance, which is peculiar to quadrupeds, chiefly covers the trunk, and, by ſuddenly ſhaking and ſhrivelling the ſkin, enables theſe animals to drive off inſects, or other offenſive bodies.

The ſubſtance of the nerves, or organs of ſenſation, is the ſame in the quadruped and in man. They originate from the brain and ſpinal marrow, and are diſtributed over all the internal and external parts of the body, in the ſame manner as in the human frame.

Thus, it appears, that, in general ſtructure and organization, the brute creation is nearly allied to the human ſpecies. Some differences, however, merit attention; becauſe a ſlight variation in ſtructure, eſpecially of the internal organs, is often accompanied with great diverſities in diſpoſitions, food, and manners.

Some animals feed upon fleſh, others upon vegetables, and others upon a mixture of both. The diſpoſitions of ſome ſpecies are fierce; and their manners convey to us the ideas of cruelty and of barbariſm: The diſpoſitions and manners of other ſpecies are ſoft and placid, and excite in us ideas of mildneſs, complacency, and innocence. The ferocity of the tyger and hyæna forms a perfect contraſt to the gentleneſs and inoffenſive behaviour of the ſheep and the ox. This oppoſition of manners has given riſe to the diſtinction of animals into rapacious and mild, carnivorous and herbivorous. In the ſtructure of theſe animals, whoſe characters are ſo oppoſite, ſome differences have been diſcovered, which indicate the intentions of Nature in forming them, and fully juſtify the ſeeming cruelty of their conduct.

In all the carnivorous tribes, the ſtomach is proportionally

* The genus Daſypus, of which there are ſeveral ſpecies.

ally ſmaller, and the inteſtines ſhorter, than in thoſe animals which feed upon vegetables. As animals of the former kind live ſolely on fleſh, the ſhortneſs and narrowneſs of their inteſtines are accommodated to the nature of their food. Animal food is more eaſily reduced to chyle, and becomes ſooner putrid, than vegetable. Of courſe, if its juices were allowed to remain long in the inteſtines, inſtead of nouriſhing the body, they would produce the moſt fatal diſtempers. Beſide this accommodation of the inteſtines to the nature of their food, carnivorous animals are furniſhed with the neceſſary inſtruments for ſeizing and devouring their prey. Their heads are roundiſh, their jaws ſtrong, and their tuſks very long, and ſharp. Some of them, as the lion, the tyger, and the whole cat-kind, are provided with long retractile claws. Thus, both the internal and external ſtructure of this claſs of animals indicate their deſtination and manners. The rapid digeſtion of their food is a conſequence of the ſtrength and ſhortneſs of their inteſtines; and the intolerable cravings of their appetite neceſſarily create a fierceneſs and rapacity of diſpoſition. Nothing leſs than blood can ſatiate them. Their cruelty, and the devaſtation they make among the weaker and more timid tribes, are effects reſulting ſolely from the ſtructure and organs with which Nature has thought proper to endow them. Hence, if there be any thing reprehenſible in the manners and diſpoſitions of the carnivorous animals, Nature alone is to blame; for all their actions are determined by the irreſiſtible impulſes of their organization. But, even in this ſeemingly-cruel arrangement, Nature muſt not be raſhly accuſed. When we come to treat of the hoſtilities of animals, I hope to be able to ſhow, that Nature, in the formation of rapacious creatures, has acted with her uſual wiſdom, and that beings of this kind have their uſes in the general ſyſtem and œconomy of the univerſe.

As to the herbivorous tribes, or thoſe animals which feed upon grain and herbage, a ſlight variation of organs produces the greateſt effects upon their diſpoſition and manners. The inteſtines of this tribe are very long, capacious, and convoluted. Vegetable food, eſpecially herbage, contains

contains a ſmaller quantity of nutritive matter than the fleſh of animals; neither is it ſo eaſily reduced to chyle. A larger quantity, therefore, as well as a longer detention in the ſtomach and inteſtines, is neceſſary for the nouriſhment of theſe creatures. Several quadrupeds comprehended under this order ruminate, or chew the cud. Theſe are furniſhed with no leſs than four ſtomachs. The food, after maſtication, is thrown into the firſt ſtomach, where it remains ſome time; after which, the animal forces it up again into the mouth, and gives it a ſecond chewing. It is then ſent directly into the ſecond ſtomach, and gradually paſſes into the third and fourth; and, laſtly, it is tranſmitted through the convolutions of the inteſtines, and the dregs, or fæces, are thrown out of the body. By this machinery, herbivorous animals are enabled to devour large quantities of vegetable aliment, to retain it long in their bowels, and conſequently to extract from it nutritive matter ſufficient for their growth, ſupport, and multiplication. Here the quantity compenſates the quality of the nutriment.

It is true, that the horſe, the aſs, the hare, and ſome other animals which live upon herbage and grain, have only one ſtomach. But, though the horſe and aſs have one ſtomach only, their inteſtines are furniſhed with ſacs or pouches ſo large, that they may be compared to the paunch of ruminating animals; and hares, rabbits, the Guiney-pig, &c. have blind guts ſo long and capacious, that they are equivalent to a ſecond ſtomach. The hedgehog, the wild boar, the ſquirrel, &c. whoſe ſtomach and inteſtines are of a mean capacity, eat little herbage, but live chiefly upon ſeeds, fruits, and roots, which contain, in ſmall bounds, a greater quantity of nutritive matter than the leaves or ſtems of plants.

The external form of herbivorous animals, like that of the rapacious, is accommodated to their diſpoſitions and the œconomy they are obliged to obſerve. That they might be enabled to reach the ſurface of the earth with eaſe, the legs of the larger kinds are proportionally ſhort; their head and neck long; and the muſcles and tendons of the neck are endowed with prodigious ſtrength. Without

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out theſe peculiarities of ſtructure, they could not ſupport the prone poſture of the head in the tedious operation of browſing large quantities of herbage. The arrangement and form of their teeth likewiſe indicate the deſtination of the ruminating tribes. They have no cutting teeth in the upper jaw; and they are totally deprived of tuſks, or canine teeth. This laſt circumſtance, joined to their want of claws, ſhews that they are not intended to prey upon other animals. Horns are the only weapons of defence with which they are provided. From the nature of their food, therefore, and the internal and external configuration of their bodies, it is evident, that animals of this deſcription muſt be humble in their deportment, and mild in their diſpoſition. This order of animals, accordingly, have uniformly been celebrated for gentleneſs of manners, ſubmiſſion, and timidity. Man has availed himſelf of thoſe diſpoſitions, by reducing almoſt the whole of this tribe to a domeſtic ſtate. But, in all this gracioufneſs of aſpect and tractability of temper, the animals themſelves have no merit. Their motions and actions are neceſſary reſults of the organs which Nature has beſtowed on them. It is obvious, therefore, that the diverſity of taſtes and diſpoſitions exhibited by different animals, ariſes not ſolely from any ſuperior agreeableneſs of particular kinds of food to their palates, or to a particular bias of their minds to benevolence and peace, but from a phyſical cauſe depending on the ſtructure of their bodies.

From what has been advanced, it follows, that man, whoſe ſtomach and inteſtines are proportionally of no great capacity, could not live upon herbage alone. It is an inconteſtible fact, however, that he can live tolerably well upon bread, herbs, and the fruits, roots, and ſeeds of plants; for we know whole nations, as well as particular orders of men, who are prohibited by their religion from eating any animal ſubſtance. But, theſe examples are not ſufficient to convince us, that the health, vigour, and multiplication of mankind would be improved by feeding ſolely upon pot-herbs and bread. Beſides, his ſtomach and inteſtines are of a mean capacity between thoſe of the carnivorous and herbivorous animals. From this circum-

circumſtance alone we are warranted to conclude, that Nature intended him to feed partly on animal and partly on vegetable, ſubſtances: And daily experience teaches us, that men fed in this manner are larger, ſtronger, and more prolific, than thoſe who are confined to a vegetable diet. If man had no other ſources of ſuperiority over the other animals than thoſe which originate from the ſtructure of his body, his diſpoſitions ought to be a medium between thoſe of the carnivorous and herbivorous tribes. When conſidered merely as an animal, this appears to be really the caſe. Vulgar and uninformed men, when pampered with a variety of animal food, are much more choleric, fierce and cruel in their tempers than thoſe who live chiefly on vegetables. Animal food heats the blood, and makes it circulate with rapidity. In this ſituation, every object capable of exciting appetite or paſſion operates with redoubled force. The weak mind yields to the impulſe, and gives vent to every ſpecies of outrage which can debaſe human nature.

In the formation of his body, man has ſome advantages over particular animals. But, theſe advantages are inconſiderable, and none of them, perhaps, are peculiar to the ſpecies. The ſtructure of all animals is nicely adjuſted to their deſtination, and the ſtation they occupy in the general ſcale of being. The body of man is erect, and his attitude is ſaid to be that of command. His majeſtic deportment, and the firmneſs of his movements, announce the ſuperiority of his rank. His arms are not mere pillars for the ſupport of his body. His hands tread not the earth; neither do they loſe, by friction and preſſure, that exquiſite delicacy of feeling for which Nature had originally intended them. His arms and hands, on the contrary, are formed for purpoſes of a more noble kind. They are deſtined for executing the commands of his will, for laying hold of bodies, for removing obſtacles, for defending him from injuries, and for ſeizing and retaining objects of pleaſure. The features of this picture are exact delineations; but they are not the excluſive privilege of man. The orang-outang walks erect, and he derives equal advantages from his hands and arms as the human

human ſpecies. Some apes have likewiſe the power of walking erect, with the additional faculty of employing their hands and arms as legs. They can walk, run, or leap, by the inſtrumentality either of two or of four extremities, as their ſituation or neceſſities may require. It is not, therefore, the fabrick of man's body that entitles him to claim a ſuperiority over the other animals. The formation of their bodies is adjuſted with equal ſymmetry and perfection to the rank they hold in the general ſyſtem of animation. Many of them excel us in magnitude, ſtrength, ſwiftneſs, and dexterity in particular movements. Their ſenſes are often more acute; they ſeize their prey, or procure herbage, fruits, and ſeeds of trees, with more facility than man, when limited to the powers of his animal nature. Hence the great ſource of man's ſuperiority over the brute creation muſt be derived from his mental faculties alone. Brutes enjoy the ſame inſtincts, the ſame appetites, and the ſame propenſities, as appear in the conſtitution of the human mind. But, the inſtincts of brutes, though they are exerted with great certainty and preciſion, are much circumſcribed with regard to extenſion and improvement. Like man, they derive advantages from experience. But, the concluſions they draw from this ſource are always feeble, and extremely limited. Neither do they poſſeſs the ineſtimable faculty of tranſmitting the knowledge acquired by individuals from generation to generation. By means of their ſenſes, they learn to diſtinguiſh their enemies, or hurtful objects, at a diſtance; and they know how to avoid them. Experience teaches them to diſcriminate objects of pleaſure from thoſe of pain; and they act according to the feelings excited by theſe objects. Some animals can even accommodate their inſtincts to particular circumſtances and ſituations. The feelings of brutes are often more exquiſite than ours. They have ſenſations; but their faculty of comparing them, or of forming ideas, is much circumſcribed. A dog or a monkey can imitate ſome human actions, and are capable of receiving a certain degree of inſtruction. But, their progreſs ſoon ſtops: Nature has fixed the boundaries of mental, as well as of corporeal, powers; and theſe boundaries

are as various as the number of diſtinct ſpecies. Our wonder is equally excited by the ſagacity of ſome animals, and by the ſtupidity of others. This gradation of mental faculties originates from the number or paucity of inſtincts beſtowed on particular ſpecies, joined to the greater or ſmaller power of extending or modifying theſe inſtincts by experience and obſervation. Man is endowed with a greater number of inſtincts than any other animal. The ſuperiority of his rank, however, does not proceed from this ſource alone. Man enjoys beyond every other animal the faculty of extending, improving, and modifying the different inſtincts he has received from Nature. It is this faculty which enables him to compare his feelings, to form ideas, and to reaſon concerning both. The bee makes cells, and the beaver conſtructs habitations of clay. The order of their architecture, however, is invariably the ſame. Man likewiſe builds houſes: But, he is not forced, by an irreſiſtible inſtinct, to work always on the ſame plan. His habitations, on the contrary, vary with the fancy of the individuals who deſign and conſtruct them.

Upon the whole, the dignity of man's rank depends not upon the ſtructure of his organs. It is from the powers of his intellect alone that he is entitled to claim a ſuperiority over the brute creation. Theſe powers enable him to form ideas, to abſtract, to reaſon, to invent, and to reach all the heights of ſcience and of art.

The remarks formerly made are applicable to quadrupeds in general. But, before concluding this branch of the ſubject, we ſhall point out a few peculiarities in the ſtructure of particular ſpecies.

Beſide the four ſtomachs common to ruminating animals, the camel and dromedary have a fifth bag, which ſerves them as a reſervoir for holding water. This bag is capable of containing a very large quantity of that neceſſary element. When the camel is thirſty, and has occaſion to macerate his dry food in the operation of ruminating, by a ſimple contraction of certain muſcles, he makes part of this water aſcend into his ſtomach, or even as high as the gullet. This ſingular conſtruction enables him

him to travel ſix, eight, or even twelve days in the ſandy deſarts, without drinking, and to take at once a prodigious quantity of water, which remains in the reſervoir pure and limpid; becauſe neither the humours of the body, nor the juices that promote digeſtion, can have acceſs to it. Beſide this ſingularity of ſtructure, the camel has two large fleſhy bunches on his back, and the dromedary, or ſwift camel, one bunch; and the feet of both are covered with a very tough, but flexible, ſubſtance. The conformation of theſe animals enables them to travel with heavy loads through the ſandy deſarts of the Eaſt, where the horſe or the aſs would inevitably periſh; becauſe Nature has not provided them with reſervoirs for holding and preſerving water, which are indiſpenſible in countries where none of that element can be procured but in particular places, that are often diſtant many days journey from each other. When we conſider the ſtructure of the camel and dromedary, we cannot be deceived with regard to their deſtination. The four ſtomachs indicate a vegetable diet, and the ſame docility and gentleneſs of manners which characteriſe the whole ruminating tribes. From the addition of a fifth bag, or reſervoir for the reception and preſervation of water, we ſhould expect to find ſome peculiarity of diſpoſition. In this conjecture we are not deceived. Of all animals which man has ſubjugated, the camel and dromedary are the moſt abject ſlaves. With incredible patience and ſubmiſſion they traverſe the burning ſands of Africa and Arabia, carrying burdens of amazing weight. Inſtead of diſcovering ſymptoms of reluctance, they ſpontaneouſly lie down on their knees till their maſter binds the unmerciful load. Arabia and ſome parts of Africa, are the drieſt and moſt barren countries in the world. Both the conſtitution and ſtructure of camels are nicely adapted to the ſoil and climate in which they are produced. The Arabians conſider the camel as a gift ſent from heaven, a ſacred animal, without whoſe aſſiſtance they could neither ſubſiſt, traffick, nor travel. The milk of the camel is their common food. They alſo eat its fleſh; and of its hair they make garments. In poſſeſſion

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ſeſſion of their camels, the Arabs want nothing, and have nothing to fear. In one day they can perform a journey of fifty leagues into the deſart, which cuts off every approach from their enemies. All the armies in the world would periſh in purſuit of a troop of Arabs. An Arab, by the aſſiſtance of his camel, ſurmounts all the difficulties of a country which is neither covered with verdure, nor ſupplied with water. Notwithſtanding the vigilance of his neighbours, and the ſuperiority of their ſtrength, he eludes their purſuit, and carries off, with impunity, all that he ravages from them. When about to undertake a depredatory expedition, an Arab makes his camels carry both his and their own proviſions. When he reaches the confines of the deſart, he robs the firſt paſſengers who come in his way, pillages the ſolitary houſes, loads his camels with the booty, and, if purſued, he accelerates his retreat. On theſe occaſions he diſplays his own talents, as well as thoſe of the camels. He mounts one of the fleeteſt, conducts the troop, and obliges them to travel day and night, without almoſt either ſtopping, eating, or drinking; and, in this manner, he often performs a journey of 300 leagues in eight days.

Another order of quadrupeds deſerves our notice. Thoſe which have been diſtinguiſhed by the appellation of amphibious, are capable of remaining a long time under water. They live chiefly upon fiſhes, and, without this faculty of continuing a conſiderable time under water, they would be unable to procure their food. To this tribe belong the ſeal *, the walrus†, the manati‡, the ſea-lion||, &c. The ſeal and walrus are more nearly allied to land-quadrupeds than to the cetaceous animals; becauſe they have four diſtinct legs, though nothing but the feet project beyond the ſkin. The toes of the feet are all connected by membranes, which enable theſe animals to ſwim in queſt of their prey. They differ from terreſtrial quadrupeds by the ſingular faculty of living with equal eaſe either in air or in water. This peculiarity of œconomy and manners preſuppoſes the neceſſity of ſome deviation

* The genus Phoca of Linnæus.

† Trichecus *Roſmarus.*

‡ Trichecus *Manatus.*

|| Phoca *Leonina.*

viation from the general ſtructure of quadrupeds; and Nature has accompliſhed this purpoſe by a very ſimple artifice.

In man, and in all land-quadrupeds, the lungs of the fœtus have no motion, and receive no more blood than is requiſite for their growth and nouriſhment. But, immediately after birth, the young animals reſpire, and the whole maſs of blood circulates through their lungs. To carry on the circulation in the fœtus-ſtate, another paſſage was neceſſary. The blood in the right auricle of the heart, inſtead of paſſing into the pulmonary artery, and, after circulating through the lungs, returning into the left auricle by the pulmonary vein, paſſes directly from the right to the left auricle through an aperture called the *foramen ovale*, which is ſituated in the partition of the heart that ſeparates the cavities of the two auricles. By this contrivance, the maſs of blood, without deviating into the lungs, enters the aorta, and is diſtributed over every part of the body. In man, and the other terreſtrial animals, the foramen ovale of the heart, which permits the fœtus to live without reſpiration, cloſes the moment after birth, and remains ſhut during life. Animals of this conſtruction can neither live without air, nor remain long under water, without being ſuffocated.

But, in the ſeal, walrus, and other amphibious animals, the foramen ovale continues open during life, though the mothers bring forth on land, and reſpiration commences immediately after birth. By means of this perpetual aperture in the ſeptum, or partition, of the heart, which allows a direct communication of the blood from the vena cava to the aorta, theſe animals enjoy the privilege of reſpiring, or not, at their pleaſure.

This ſingularity in the ſtructure of the heart, and the conſequent capacity of living equally on land and in water, muſt neceſſarily produce ſome peculiarities in the manners and diſpoſitions of amphibious animals. The ſeal, accordingly, whoſe hiſtory is beſt known, may be conſidered as holding the empire of the ſilent ocean. To this dignity he is entitled by his voice, his figure, and his intelligence, which render him ſo ſuperior to the fiſhes,

fiſhes, that they ſeem to belong to another order of beings. Though his œconomy be very different from that of our domeſtic animals, he is ſuſceptible of a ſpecies of education. He is reared by putting him frequently in water. He is taught to give a ſalute with his head and his voice. He approaches when called upon. His ſenſes are equally acute as thoſe of any quadruped; and, of courſe, his ſenſations and intellect are equally active. Both are exhibited in the gentleneſs of his manners, his ſocial diſpoſition, his affection for the female, his anxious attention to his offspring, and the expreſſive modulation of his voice. Beſides, he enjoys advantages which are peculiar to him. He is neither afraid of cold nor of heat. He lives indifferently on herbs, fleſh, or fiſh. He inhabits, without inconvenience, water, land, or ice. When aſſiſtance is neceſſary, the ſeals underſtand and mutually aſſiſt one another. The young diſtinguiſh their mother in the midſt of a numerous troop. They know her voice; and, when ſhe calls, they never fail to obey.

Before diſmiſſing this branch of the ſubject, the elephant muſt not be paſſed over in ſilence. His ſtructure is uncommon, and ſo are his talents. The elephant is the largeſt and moſt magnificent animal that at preſent treads the earth. Though he daily devours great quantities of herbage, leaves, and branches of trees, he has but one ſtomach, and does not ruminate. This want, however, is ſupplied by the magnitude and length of his inteſtines,and particularly of the colon, which is two or three feet in diameter by fifteen or twenty in length. In proportion to the ſize of the elephant, his eyes are very ſmall; but they are lively, brilliant, and capable of a pathetic expreſſion of ſentiment. He turns them ſlowly, and with mildneſs, toward his maſter. When he ſpeaks, the animal regards him with an eye of friendſhip and attention. He ſeems to reflect with deliberation, and never determines until he has examined, without paſſion or precipitation, the orders which he is deſired to obey. The dog, whoſe eyes are very expreſſive, is too prompt and vivacious to allow us to diſtinguiſh with eaſe the ſucceſſive ſhades of his ſenſations. But, as the elephant is naturally grave and moderate,

rate, we perceive in his eyes the order and fucceffion of his thoughts. His ears are very large, and much longer, even in proportion to his body, than thofe of the afs. They lie flat on the head, and are commonly pendulous; but he can raife and move them with fuch facility, that he ufes them as a fan to cool himfelf, and to defend his eyes from duft and infects. His ear is likewife remarkably fine; for he delights in the found of mufical inftruments, and moves in cadence to the trumpet, and tabour.

But, in the ftructure of the elephant, the moft fingular organ is his trunk, or probofcis. It is compofed of membranes, nerves, and mufcles; and it is at once an inftrument of feeling and of motion. The animal can not only move and bend the trunk, but he can contract, lengthen, and turn it on all fides. The extremity of the trunk terminates in a protuberance that ftretches out on the upper fide in the form of a finger; by means of which he lifts from the ground the fmalleft pieces of money; he felects herbs, and flowers, and picks them up one by one; he unties the knots of ropes, opens and fhuts gates by turning the keys, or pufhing back the bolts. In the middle of this protuberance or finger, there is a cavity in the form of a cup, and, in the bottom of the cup are the apertures of the two organs of fmelling and refpiration. This hand of the elephant poffeffes feveral advantages over that of the human. It is more flexible, and equally dexterous in laying hold of objects. Befides, he has his nofe in his hand, and is enabled to combine the power of his lungs with the action of his finger, and to attract fluids by a ftrong fuction, or to raife heavy bodies by applying to them the edge of his trunk, and making a vacuum within by a vigorous infpiration. Hence, delicacy of feeling, acutenefs of fmelling, facility of movement, and the power of fuction, are united at the extremity of the elephant's trunk. Of all the inftruments which Nature has beftowed on her moft favourite productions, the trunk of the elephant feems to be the moft complete, as well as the moft admirable. It is not only an organic inftrument, but a triple fenfe, whofe united functions exhibit the effects of that wonderful fagacity which exalts the elephant above all other quadrupeds.

peds. He is not ſo ſubject, as ſome other animals, to errors of viſion; becauſe he quickly rectifies them by the ſenſe of touch; and, by uſing his trunk as a long arm, for the purpoſe of touching remote objects, he acquires, like man, clear ideas of diſtances. But, other animals, except ſuch as have a kind of arms and hands, can only acquire ideas of diſtances by traverſing ſpace with their bodies. Delicacy of feeling, the flexibility of the trunk, the power of ſuction, the ſenſe of ſmelling, and the length of the arm, convey ideas of the ſubſtance of bodies, of their external form, of their weight, of their ſalutary or noxious qualities, and of their diſtances. Thus, by the ſame organs, and by a ſimultaneous act, the elephant feels, perceives, and judges of, ſeveral things at one time. It is by virtue of this combination of ſenſes and faculties in the trunk that the elephant is enabled to perform ſo many wonderful actions, notwithſtanding the enormity of his maſs, and the diſproportions of his form. The thickneſs and rigidity of his body; the ſhortneſs and ſtiffneſs of his neck; the ſmallneſs of his head; the largeneſs of his ears, noſe, and tuſks; the minuteneſs of his eyes, mouth, genitals, and tail; his ſtraight, clumſey, and almoſt inflexible limbs; the ſhortneſs and ſmallneſs of his feet; the thickneſs and calloſity of his ſkin; all theſe deformities are the more obvious and diſagreeable, becauſe they are modelled on a large ſcale, and moſt of them are peculiar to the elephant.

From this ſingular conformation, the animal is ſubjected to many inconveniences. He moves his head with difficulty, and cannot turn back without making a large circuit. For this reaſon, the hunters attack him behind, or on the flanks, and avoid the effects of his rage by circular movements. He cannot ſeize any object on the ground with his mouth, becauſe his neck is too ſtiff to allow his head to reach the earth. He is, therefore, obliged to lay hold of his food, and even of his drink, with his noſe, and then convey them to his mouth. It is likewiſe a conſequence of this ſtructure, that the young elephants are ſaid to ſuck with their noſe, and afterwards pour the milk into their gullet.

OF

OF THE STRUCTURE OF BIRDS.

FROM the figure and movements of the feathered tribes, we ſhould be led to imagine that the ſtructure of their organs was extremely different from that of quadrupeds. Their œconomy and manner of living required ſome variations in their frame. But thoſe variations are by no means ſo many or ſo great as might be expected. Inſtead of hairs, their bodies are covered with feathers, which, beſide the beautiful variety of their colours, protect this claſs of animals from the aſſaults of rain and cold. They have only a couple of legs; but Nature has furniſhed them with two additional inſtruments of motion, by which they are enabled to riſe from the ſurface of the earth, and to fly with amazing rapidity through the air. The wings are articulated with the breaſt-bone, and their motions are performed by muſcles of remarkable ſtrength. Many birds are continually paſſing through hedges and thickets. To defend their eyes, therefore, from external injuries, as well as from too much light when flying in oppoſition to the rays of the ſun, they are furniſhed with a membrane called *membrana nictitans*, which, like a curtain, can at pleaſure be drawn over the whole eye. This covering is neither opaque nor pellucid; but, being ſomewhat tranſparent, it allows as many rays to enter as render any object juſt viſible, and enable them to direct their progreſs through the air. It is by the inſtrumentality of this membrane that the eagle looks at the ſun. The feathers of all birds are inſerted into the ſkin in ſuch a manner that they naturally lie backward from the head; and allow the rain to run off their bodies, and, by turning their heads in oppoſition to the wind, prevent the wind from rumpling their feathers, and retarding their flight. Beſide this proviſion, the rump of birds terminates in a large gland, which ſecretes an oily ſubſtance. When the feathers are too dry, or any way diſordered, the animals ſqueeze this gland with their bills,

extract

extract the oil, and with it they befmear and drefs the feathers. By this means the admiffion of water is totally prevented. Birds have no feparate ribs; but the breaft-bone, which is very large, joins the back-bone, and fupplies their place.

With regard to the external figure of birds, the form of their bodies is nicely adapted to their manners, and the mode of life they are deftined to purfue. By ftriking the air with their wings, they move forward in that element, and their tail ferves them as a rudder to direct their courfe. Their breaft-bone, inftead of being flat, rifes gradually from the fpine and terminates in a fharp ridge, or keel, which enables them to cut the air with greater facility. For the fame purpofe, the heads of birds are proportionally fmaller than thofe of quadrupeds, and moft of them terminate in light fharp-pointed beaks. They are likewife deprived of external ears *, and of protuberant noftrils. Their tails, inftead of vertebræ, mufcles, and fkin, confift entirely of feathers. They have no pendulous fcrotum, no bladder, no flefhy uterus. Neither have they an epiglottis, though many of them poffefs great powers of modulation, and fome of them may even be taught to articulate words. To lighten their beaks, they are deprived of lips and teeth; and their abdomen or belly is proportionally fmall and narrow.

From this general view of the external figure and ftructure of birds, it is apparent, that Nature has defigned them for two diftinct kinds of motion. They can, at pleafure, either walk on the furface of the earth, or mount aloft, and penetrate the airy regions with prodigious fwiftnefs.

Some peculiarities in the internal ftructure of birds deferve our notice.

Like quadrupeds, the feathered tribes are divided into granivorous and carnivorous; and their manners and difpofitions correfpond with their internal and external conformation.

In

* Although birds are deftitute of external ears, properly fo called, yet in the greater number of this extenfive clafs of animals the *meatus auditorius*, or external orifice leading to the ears, is furrounded by feathers which are elegantly difpofed, like diverging radii, and appear to be peculiarly adapted for receiving found.

In the granivorous clafs, the œfophagus, or gullet, runs down the neck, and terminates in a pretty large membranous fac, called the *ingluvies*, or craw, where the food is macerated, and partly diffolved by a liquor fecreted from glands fpread over the furface of this fac. Some birds, as the rooks and the pigeon kind, have the power of bringing up the food from this fac into their mouths, and feeding their young with it in a half-digefted form. After macerating for fome time, the food paffes through the remainder of the gullet into another fpecies of ftomach denominated *ventriculus fuccenturiatus*, which is a continuation of the gullet. Here the food receives a farther dilution. From this fecond ftomach, the food is tranfmitted to the gizzard, or true ftomach, which confifts of two very ftrong mufcles, covered externally with a tendinous fubftance, and lined with a thick, firm membrane. The remarkable ftrength of the gizzard was formerly fuppofed to affift the digeftion of granivorous birds by attrition. But, this notion has of late been entirely exploded; for Doctor Stevens, and, after him, Spallanzani, have demonftrated, by unequivocal experiments, that digeftion is performed folely by the diffolving powers of the gaftric juices *. The other inteftines are proportionally larger, and much longer, than thofe of the carnivorous birds.

The ftructure of the heart, in granivorous birds, is nearly the fame with that of quadrupeds.

The lungs hang not loofe in the cavity of the thorax, but are fixed to the back-bone: Neither are they divided into lobes, as in man and other animals whofe fpines admit of confiderable motion. They are red, fpongy bodies, covered with a membrane that is pervious, and communicates with the large veficles, or air-bags, which are fpread over the whole abdomen. Thefe veficles, when diftended with air, render the bodies of birds fpecifically light. They likewife fupply the place of a diaphragm, and ftrong abdominal mufcles. They produce the fame effects on the vifcera as thefe mufcles would have done,

 without

* See Stevens Differt. Med. Inaug. De Alimentorum Concoctione, Edin. 1777, and Spallanzani. S.

without the inconveniency of giving an additional weight to the body.

Birds have no bladder of urine: But a bluiſh-coloured canal, or ureter, is ſent off from each kidney, and terminates in the rectum. Their urine is diſcharged along with the fæces. It is a whitiſh ſubſtance, and turns chalky when expoſed to the air.

The teſticles of the male are ſituated on each ſide of the back-bone, and are very large in proportion to the ſize of the animal. From the teſticles proceed two ſeminal ducts, which at firſt are ſtraight, but afterwards acquire a convoluted form, as in the epidydymus of man. Theſe ducts terminate in the penis, of which the cock has two, one on each ſide of the common cloaca. They are very ſmall and ſhort; and, from this circumſtance, they long eſcaped the notice of anatomiſts.

In the female, the cluſter of yolks, being analogous to the human ovaria, are attached to the back-bone by a membrane. This membrane is very thin, and continues down to the uterus. The yolk, after ſeparating from its ſtalk, paſſes into a canal called the *infundibulum*, where it receives a gelatinous liquor, which, with what it farther acquires in the uterus, compoſes the white of the egg. The uterus is a large bag, ſituated at the end of the infundibulum, and is full of wrinkles on the inſide. Here the egg receives its laſt covering, or ſhell, and is puſhed out of the vagina at an aperture placed immediately above the anus.

From this deſcription of the ſtructure of granivorous birds, the analogy between them and the herbivorous quadrupeds is conſpicuous. In both, the number of their ſtomachs, the length and capacity of their inteſtines, and the quality of their food, are very ſimilar. But, this analogy is not confined to ſtructure and organs: It extends to manners and diſpoſitions. Like the herbivorous quadrupeds, this order of birds are diſtinguiſhed by the gentleneſs and complacency of their tempers. Contented with the ſeeds of plants, or ſmall inſects, the ſtronger never wage war with the weaker. Their chief attention is occupied in procuring food, in hatching and rearing

their

their young; and their vigilance is kept perpetually active in eluding the ſnares of men, and other rapacious animals. The whole are a timid race, and many of them are ſo tractable that they may eaſily be rendered domeſtic. Man, accordingly, ever attentive to his intereſt, has not failed to derive advantage from the innocence and ſtupidity of theſe animals. Of the gallinaceous and duck kind, which are the moſt prolific, and conſequently the moſt profitable, he has chiefly ſelected the hen, the gooſe, the duck, the turkey, and the peacock. In this ſelection he has diſcovered his ſagacity; for, inſtead of pairing, theſe birds are polygamous, one male being ſufficient to fertilize a number of females, which is a great ſaving in the article of food.

With regard to carnivorous birds, their general conformation is nearly the ſame with that of the granivorous kind. They have the ſame number of ſtomachs; but all of them are ſmaller, and weaker. Their inteſtines are alſo much ſhorter. To enable them to procure food, they are obliged to fly quickly, and continue long on the wing. Their wings, accordingly, are proportionally longer, and they have more ſtrength in their muſcles. For the purpoſe of ſeizing and devouring prey, Nature has beſtowed on them ſtrong hooked bills, and long ſharp claws, or pounces. They have alſo large heads, ſhort necks, ſtrong brawny thighs, and ſharp-ſighted eyes.

Like rapacious quadrupeds, birds of prey are capable of enduring hunger for a great length of time. This faculty is, perhaps, acquired partly by habit; becauſe the obtaining of their food is often very precarious. The females are larger, ſtronger, and more beautiful both in ſhape and plumage, than the males. For this reaſon, the male hawks are called *tercels*, or *thirds*, becauſe they are ſuppoſed to be one third leſs than the females. Nature ſeems to have beſtowed this ſuperiority of ſize and ſtrength upon the female, becauſe ſhe is obliged to procure food both for herſelf and for her progeny.

The analogy between the ſtructure of rapacious birds and carnivorous quadrupeds is obvious. Both of them are provided with weapons which indicate deſtruction and rapine.

rapine. Their manners are also fierce and unsocial. They never, if the vulture be excepted, herd together in flocks, like the inoffensive granivorous tribes. When not on the wing, they conceal themselves on the top of sequestered rocks, or in the depths of the forests, where they spend their time in sullen solitude. Those of them which feed upon carrion, as the raven, have the sense of smelling so acute, that they scent dead carcases at amazing distances.

Beside these great divisions of birds into granivorous and rapacious, whose manners and dispositions perfectly coincide with the structure of their bodies, there are other tribes to whom Nature has given peculiar organs. In all these deviations from the common structure, a singularity in the mode of living, and the œconomy of the animal, is the invariable result.

Like the amphibious animals, a number of fowls live chiefly in the water, and feed upon fishes and aquatic insects. To enable them to swim and to dive in quest of food, their toes are connected together by broad membranes, or webs. By stretching their toes, and striking the water backward with these webs, their bodies are moved forward, and they employ their tail as a rudder to direct their course. Without these additional instruments, fowls could not swim; and, accordingly, such birds as are not provided with webs never take to the water. But, those furnished with webs have such a strong propensity to water, that, when restrained from their favourite element, they discover the greatest uneasiness, and, when their liberty is restored, they fly in a direct course either to the sea, a river, or a lake.

There is another tribe of aquatic birds, some of which feed upon fishes and insects, and others live principally by sucking certain juices from mud. Both these kinds frequent marshy places, or the margins of lakes and rivers. They do not swim, but wade, in quest of food. This singularity in their manners required a correspondent variation in their form and structure. To enable them to wade in waters and in mires, Nature has provided them with long legs, naked of feathers for a considerable space above the knees. Their toes are not, like those of the swimmers,

ſwimmers, connected by continued membranous webs. Moſt of them have likewiſe very long necks and bills, to enable them to ſearch for and apprehend their food. To theſe tribes belong the crane, the herons, the bittern, or miredrum, the ſtork, the ſpoon-bill, the woodcock, the ſnipe, and many other ſpecies.

Having given a general idea of the ſtructure and œconomy of birds, we ſhall next make a few remarks on the form and manners of fiſhes.

OF THE STRUCTURE AND ORGANS OF FISHES.

IT is one great and benevolent intention of Nature, that no part of the univerſe ſhould be deprived of inhabitants. The earth, the air, the waters, are full of living beings, who are not only conſcious of their exiſtence, but enjoy degrees of happineſs proportioned to their natures, and the purpoſes they are deſtined to anſwer in the general ſcale of animation. The different elements in which they live neceſſarily required a variety in their form, their food, and their manners. The inhabitants of the earth and air have already been partially deſcribed: thoſe of the waters are next to be conſidered.

The bodies of moſt fiſhes are covered with a ſtrong, thick ſkin, in which numberleſs ſcales are inſerted in an imbricated form, or like tiles on the roofs of houſes. Many of them, and particularly thoſe which are ſhaped like the cod, the trout, and the haddock, have a longitudinal line on each ſide. In theſe lines there are a number of ſmall ducts, or apertures, which throw out a mucous ſubſtance that lubricates their ſkins, and ſeems to anſwer the ſame purpoſes as the mucous glands or ducts placed in moſt of our internal organs.

Fiſhes are deſtitute of hands and feet. Their progreſſive motion, therefore, is performed in a manner different from that of quadrupeds and birds. Their inſtruments of motion are fins, or machines conſiſting of a number of elaſtic beams, connected to one another by firm membranes

branes. Their tails are of the ſame texture. Their ſpine is remarkably flexible toward the poſterior part of the body, and here the ſtrongeſt muſcles are likewiſe inſerted. They have a power of contracting and dilating their tails at pleaſure; by which means, and by the aſſiſtance of the fins, they move forward in the ſame manner as a boat with oars on its ſides, and a rudder at its ſtern. Fiſhes have no neck: As they ſeek their food in a horizontal poſition, and can move their bodies either upward or downward, a long neck would neceſſarily have impeded their motion through the water.

The form of fiſhes is extremely various; and, if their hiſtory were ſufficiently known, the connection between their ſtructure and their manners would be equally apparent as in the other tribes with which we are better acquainted. Some fiſhes are long and cylindrical, as the ſea-ſerpent, and all the eel-ſhaped ſpecies. The eel-kind, from their figure, are enabled to trail their bodies along the bottom, and to conceal themſelves below the ſand, or mud. Others are leſs cylindrical, and proportionally ſhorter, as the mackrel, the cod, the herring, the ſalmon, &c. Theſe, from the number and poſition of their fins, as well as from the ſhape of their bodies, are deſtined for quicker motion, and for travelling to great diſtances in queſt of food, or for ſpawning in ſhoals or in rivers. Others, as the flounder, the ſkate, the turbet, torpedo, &c. are broad and compreſſed. Theſe, like the eel-kind, frequent muddy bottoms. Others are triangular, quadrangular, round, &c. Beſide thoſe which approach to regular figures, the variations and compoſitions are ſo numerous, that the forms of fiſhes are much more diverſified than thoſe of quadrupeds, or birds. To defend themſelves againſt their enemies, many fiſhes are armed with ſtrong, ſharp ſpines, or prickles. For the ſame purpoſe, and likewiſe for wounding, or killing their prey, ſome have a large horn on their front, and others a ſword, or rather a ſaw, which are tremendous weapons. The more timid and defenceleſs tribes are endowed with the faculty of rapid motion; and ſome of them have fins ſo large and flexible, that, when hard purſued, they are enabled to leave their natural

natural element, to dart through the air to confiderable diftances, and difappoint the defigns of their enemies.

Fifhes are as much diverfified in fize as in figure. The ocean produces the largeft animals which now inhabit this globe. The enormous maffes of the whale and walrus tribes far exceed thofe of the elephant, rhinoceros, or river-horfe, the largeft terreftrial animals of which we have any proper knowledge. From the immenfe bones, however, found in Siberia, and many parts of Europe, we are induced to believe, that land animals have formerly exifted whofe fize muft have been much larger than that of the prefent elephant. This animal, whofe fpecies is now fuppofed to be extinguifhed, is known among naturalifts by the denomination of the *mammouth*. Near the river Ohio, fome prodigious bones and teeth have lately been difcovered, which indicate an animal of incredible magnitude*.

With regard to internal ftructure, fifhes, like land-animals, are furnifhed with a back-bone and ribs, which run from the head to the tail. To thefe, the bones of the head, and the fins, all the mufcles and inftruments of motion, are attached.

The mouths of moft fifhes are furnifhed with teeth; but in fome, as the mullet, fturgeon, &c. the teeth are wanting. In fome, the teeth are fituated on the jaw-bones, in others, on the tongue and palate. The teeth of fifhes are principally defigned for laying hold of and detaining their prey, which they generally fwallow entire. For this purpofe, the teeth are commonly ferrated, or bent inward, like tenter-hooks. By this ftructure, fmall fifhes are eafily forced downwards, and their return is at the fame time prevented.

In fifhes, the organ of fmelling is large; and they have a power of contracting and dilating, at pleafure, the entry into their nofe.

It was formerly doubted whether fifhes were endowed with the fenfe of hearing. But, that doubt is now fully removed; becaufe it has been found, that, like other animals,

* A Memoir on the fubject of thefe large American bones will foon be laid before the Philofophical Society of this city.

animals, they have a complete organ of hearing, and that water is a proper medium for the conveyance of ſound. Beſides, in the ſkate, and ſome other genera, the learned and ingenious Dr. Monro, Profeſſor of Anatomy in the College of Edinburgh, has lately diſcovered an aperture which leads directly to the internal parts of the ear.

The gullet of fiſhes is ſo ſhort that it is hardly to be diſtinguiſhed from the ſtomach, which is of an oblong figure. The guts are very ſhort, making only three convolutions, the laſt of which terminates in the common vent for the fæces, urine, and ſemen. From this ſtructure of the ſtomach and inteſtines, analogy would lead us to conclude, that fiſhes live chiefly upon animal food. Experience, accordingly, teaches us, that almoſt all fiſhes prey upon the ſmaller kinds, and even devour their own young. The liver is proportionally large, of a whitiſh colour, and ſituated on the left ſide. The gall-bladder lies at a conſiderable diſtance from the liver, and diſcharges the gall into the gut. In fiſhes, the organs of generation are two bags ſituated in the abdomen, and uniting near the anus. In the male, theſe bags are filled with a thick whitiſh ſubſtance called the *milt*, and in the female with an infinite number of minute eggs called the *roe*. At the ſeaſon of ſpawning, the bags of both male and female are greatly diſtended; but, at other times, the male organs can ſcarcely be diſtinguſhed from thoſe of the female.

The ſwimming bladder is an oblong, white, membranous bag, which contains nothing but a quantity of elaſtic air. It lies cloſe to the back-bone, and has a pretty ſtrong muſcular coat. By contracting this coat, and, of courſe, condenſing the air it contains, ſome fiſhes are enabled to render their bodies ſpecifically heavier than water, and to ſink to the bottom; and, when the muſcular fibres ceaſe to act, the air dilates, and makes their bodies ſpecifically lighter. By this curious piece of mechaniſm, the animals have the power of ſinking to the bottom, or of riſing to the ſurface. According to the different degrees of contraction and dilatation of this bladder, fiſhes can, at pleaſure,

ſure, keep themſelves higher or lower in the water. Hence flounders, ſoles, ſkate, and other fiſhes which have no ſwimming bladder, always grovel at or near the bottom. It is likewiſe a conſequence of the relaxation of this bladder, that dead fiſhes which are furniſhed with it uniformly riſe to the ſurface. The air-bag, in ſome fiſhes, communicates, by a duct, with the gullet, and, in others, with the ſtomach. At the upper end of the air-bag, there are red-coloured glandular bodies connected with the kidneys. From the kidneys the ureters proceed downward to their inſertion in the urinary bladder, which lies in the lower part of the abdomen, and the urethra terminates in the anus.

Fiſhes have a membranous diaphragm, or midriff, that forms a ſack in which the heart is contained. The heart is of a triangular figure. It has only one auricle, one ventricle, and one great artery. This artery, inſtead of ſupplying all the parts of the body, as in the frog, is diſtributed entirely on the gills. All the branches terminate there, and become at laſt ſo ſmall that they eſcape the naked eye. The branchiæ, or gills, lie in two large ſlits on each ſide of the head, and are analogous to the lungs of land-animals. The figure of the gills is ſemicircular, and on each ſide of them are immenſe numbers of fibrils, reſembling fringes. The gills are perpetually ſubjected to an alternate motion from the preſſure of the water, and the action of the muſcles. They are covered with a large flap, which allows an exit to the water neceſſarily taken in by the animals every time their mouths are opened. The blood is again collected by a vaſt number of ſmall veins, which, inſtead of going back a ſecond time to the heart, immediately unite, and form an aorta deſcendens, which ſends off branches to ſupply all the parts of the body, except the gills. From the extremities of theſe branches the blood is collected by veins, and returned to the heart nearly in the ſame manner as in other animals.

The organs by which the nutritious part of the food of fiſhes is extracted and conveyed to the general maſs of blood, and known by the names of lacteal, abſorbent, and lymphatic, veſſels, are ſo analogous to thoſe of men

and quadrupeds, that it is unneceſſary to deſcribe them *. For the ſame reaſon, no deſcription ſhall be given of the nerves, which, as in other animals, proceed from the brain and ſpinal marrow, and are diſtributed over every part of the body.

Having finiſhed this ſketch of the ſtructure and organs of fiſhes, it is almoſt needleſs to remark, that, though they live in a different element, and vary greatly from land-animals in figure, Nature, in the formation of their bodies, in the mode of their nutrition, reſpiration, and ſenſation, has acted upon the ſame great and general plan.

We are, now, to take a view of the ſtructure of inſects, a numerous claſs of animals, moſt of whom recede farther from the common mode of organization than any of the other claſſes.

OF THE STRUCTURE OF INSECTS.

IN the firſt chapter, a few obſervations were made concerning the ſtructure and organs of inſects, in order to ſhow more clearly the analogies between animals and vegetables. Theſe it is unneceſſary to repeat. We ſhall, therefore, proceed to a more particular examination of the ſtructure of inſects, and to trace the connection between that and their manners.

Inſects exhibit ſuch an immenſe variety in figure, colour, and diſpoſition of parts, that Naturaliſts have found it neceſſary to arrange them into different tribes, or families. Theſe tribes are diſtinguiſhed from one another by certain peculiarities in the ſtructure of their bodies.

The moſt general diviſion of inſects is derived from the

* It may not, however, be improper to obſerve, that the conglobate, or lymphatic glands, which ſeem to conſtitute an eſſential part of the abſorbent ſyſtem in man, in quadrupeds, and in birds, have not, hitherto, been diſcovered in any genus of fiſhes. But, in fiſhes, and in the amphibious animals, which are likewiſe deſtitute of theſe glands, the lymphatics form a great number of plexus ; and the progreſs of the lymph being thus retarded, M. Maſcagni ſuppoſes that all the uſes of theſe glands are anſwered by this peculiar arrangement of the veſſels themſelves. Birds have but few conglobate glands : but, to make amends for this circumſtance, Nature has formed the lymphatics of this claſs of animals into frequent plexus, ſomewhat reſembling net-work.

the circumſtance of their having or wanting wings, and from the number and ſubſtances of which theſe inſtruments of motion are compoſed. They are diſtinguiſhed from all other animals by many peculiarities of form. None of the other claſſes have more legs than four. But, moſt inſects have ſix; and many of them have eight, ten, fourteen, ſixteen, eighteen, and even a hundred, legs. Beſide the number of legs, inſects are furniſhed with antennæ, or feelers. Theſe feelers, by which inſects grope and examine the ſubſtances they meet with, are compoſed of a great number of articulations, or joints. Linnæus, and other naturaliſts, maintain, that the uſes of theſe feelers are totally unknown. But, the ſlighteſt attention to the manner in which ſome inſects employ their feelers, will ſatisfy us of at leaſt one uſe they derive from theſe organs. When a wingleſs inſect is placed at the end of a twig, or in any ſituation where it meets with a vacuity, it moves the feelers backward and forward, elevates, depreſſes, and bends them from ſide to ſide, and will not advance farther, leſt it ſhould fall. Place a ſtick, or any other ſubſtance, within reach of the feelers; the animal immediately applies them to this new object, examines whether it is ſufficient to ſupport the weight of its body, and inſtantly proceeds in its journey. Though moſt inſects are provided with eyes, yet the lenſes of which they conſiſt are ſo ſmall and convex, that they can ſee diſtinctly but at ſmall diſtances, and, of courſe, muſt be very incompetent judges of the vicinity or remoteneſs of objects. To remedy this defect, inſects are provided with feelers, which are perpetually in motion while the animals walk. By the ſame inſtruments, they are enabled to walk with ſafety in the dark.

No other animals but the inſect tribes have more than two eyes. Some of them have four, as the phalangium; others, as the ſpider and ſcorpion, have eight eyes. In a few inſects, the eyes are ſmooth; in all the others, they are hemiſpherical, and conſiſt of many thouſand diſtinct lenſes. The eyes are abſolutely immoveable: But, this defect is ſupplied by the vaſt number of lenſes, which, from the diverſity of their poſitions, are capable of view-

ing

ing objects in every direction. By the ſmallneſs and convexity of theſe lenſes, which produce the ſame effect as the object glaſs of a microſcope, inſects are enabled to ſee bodies that are too minute to be perceived by the human eye.

Another peculiarity deſerves our notice. No animal, except a numerous tribe of four-winged inſects, has more than two wings.

With regard to ſex, quadrupeds, birds, and fiſhes, are diſtinguiſhed into males and females. But, the bee and the ant furniſh examples of neuters, which are abſolutely barren: And the earth-worm, and ſeveral ſhell-inſects, are hermaphrodite, each individual poſſeſſing the prolific powers of both male and female.

It is likewiſe remarkable, that all winged inſects undergo three metamorphoſes, or changes of form: The egg is diſcharged from the body of the female in the ſame manner as in other oviparous animals. By a wonderful inſtinct, theſe ſeemingly-ſtupid creatures uniformly depoſit their eggs on ſuch animal or vegetable ſubſtances as furniſh proper food for the worm or caterpillar, that is to be hatched by the heat of the ſun. The worm, or caterpillar, is the firſt ſtate. The bodies of caterpillars are ſoft and moiſt. They have no wings, and are totally deprived of the faculty of generation. After continuing for ſome time in this reptile ſtate, they are transformed into a chryſalis, which is drier and harder than the caterpillar. The chryſales of ſome inſects are naked, and thoſe of others are covered with a ſilken web, ſpun by the animals before their change is completed. In this ſtate, many of them lie motionleſs, and ſeemingly inanimate, during the whole winter. When the ſpring or ſummer heats return, they burſt from their laſt priſon, and, from vile reptiles, are transformed into beautiful flies. In this perfect ſtate they are exceedingly active, fly about in queſt of their mates, and, after propagating their ſpecies, the females depoſit their eggs, and the ſame circle of animation and change perpetually goes round. Hence, the ſtructure and figure of the ſame individual animals are threefold, which renders the knowledge of inſects extremely complicated, as we muſt be acquainted

quainted with them in the ſeveral forms they ſucceſſively aſſume.

There is another peculiarity in the ſtructure of inſects. They are deprived of bones. But, that defect is ſupplied, in ſome, by a membranous or muſcular ſkin, and, in others, by a cruſtaceous or horny covering. In this circumſtance, inſects reſemble the ſhell-animals, whoſe bones conſtitute the external parts of their bodies.

In general, the bodies of inſects are compoſed of a head, trunk, and abdomen. The head is commonly attached to the trunk by a joint, or articulation. Beſide eyes, feelers, and mouth, the heads of ſome inſects are furniſhed with *palpi* fixed to the mouth; and they are either four or ſix in number. Each of them conſiſts of two, three, or four, joints, and are often miſtaken for the antennæ, or feelers. Theſe inſtruments ſeem to ſerve the animals inſtead of hands; for they employ the palpi to bring the food to their mouths, and to keep it ſteady while eating. It is aſſerted by Linnæus, and other naturaliſts, that the heads of inſects are deſtitute of brains, noſtrils, and ears. The minuteneſs of the animals under conſideration may have hitherto prevented us from diſtinguiſhing theſe organs. If they want a brain, it is certain that their ſenſe of ſeeing is acute; and we know that they are amply ſupplied with nerves, which produce the ſame effects as the brain in larger animals. If they are deprived of noſtrils, the ſlighteſt attention muſt convince us, that ſome of them poſſeſs the ſenſe of ſmelling in a very high degree. Upon any other ſuppoſition, how ſhould the different ſpecies of flies, the moment they eſcape from the chryſalis ſtate, diſtinguiſh, and directly approach, the different animal and vegetable ſubſtances Nature has deſtined for their reſpective nouriſhment? A piece of meat is no ſooner expoſed to the air than it is covered with fleſh-flies, upon which they both feed and depoſit their eggs. Without this ſenſe, how ſhould waſps, and other flies, be allured from conſiderable diſtances into bottles encruſted with honey, or molaſſes? Theſe, and ſimilar actions, cannot be effects of ſight; for the diſtance, the minuteneſs, and frequently the poſition

poſition of the food, render it impoſſible for the eye to diſcover thoſe ſubſtances to which they inſtantly reſort.

With regard to hearing, it is more difficult to determine whether inſects be endowed with this ſenſe. We can judge of it, not by the knife of the Anatomiſt, but by the affections and motions of the animals themſelves. Several trials I have made on houſe-flies incline me to think that theſe animals poſſeſs a ſenſe of a nature ſimilar, at leaſt, to that of hearing. At the diſtance of three or four feet, a ſmart ſtroke, even upon a ſtone wall, alarms and puts them to flight. But, this may partly be attributed to the vibration in the wall, or the concuſſion of the air, produced by the ſtroke. To obviate this difficulty, at the ſame diſtance of between three and four feet, I ſtruck the air repeatedly with a bookbinder's folder, without giving the ſmalleſt alarm to the flies. But, when I ſtruck the folder againſt the boards of a book, which I held in my hand, and made a ſmart noiſe, the animals were inſtantly alarmed, and flew off at the ſecond ſtroke. The ſame effect is produced in a room juſt light enough to render the animals viſible. Theſe trials, which I have often repeated, ſeem to indicate that flies, if they are really deprived of ears, are endowed with an analogous ſenſe, though we are ignorant of its ſituation*.

Naturaliſts have limited the ſenſes of inſects to thoſe of ſeeing and feeling. But, the above remarks render it more than probable that flies poſſeſs likewiſe the ſenſes of ſmelling and of hearing: Neither ſhould the ſenſe of taſte be denied them; for, though they may be aſſiſted by ſmelling to diſcover and ſelect their food, we cannot ſuppoſe that Nature has denied them the pleaſure which other animals ſo univerſally derive from eating. Beſides, an agreeable ſenſation, ſimilar to that of taſte, muſt accompany

* The very learned and laborious Profeſſor Fabricius of Copenhagen, who has, perhaps, added more to the maſs of our knowledge concerning inſects than any perſon now living, has been ſo fortunate as to diſcover the *organs of hearing* in the *lobſter*, and in the *crab*. In theſe animals, the external orifice of the organs is placed between the long and the ſhort antennæ; whilſt the cochlea, &c. are ſituated in the upper part of the thorax (as it is called by Linnæus), near the baſe of the ſerrated projection at its apex, or point. For a particular account of this curious diſcovery in the hiſtory of inſects, the reader is referred to the ſecond volume of the *New Copenhagen Tranſactions*, p. 375.

pany an action which removes the pain arifing from hunger.

The mouth of infects is generally placed in the under part of the head; but, in fome, it is fituated in the breaft. The jaws, inftead of being horizontal, are often tranfverfe, and furnifhed with teeth. The greater number of winged infects are provided with a probofcis, or trunk, an inftrument by which they extract the juices from animal or vegetable fubftances. The probofcis of infects is a machine of a very complicated nature. In butterflies, the probofcis is fituated precifely between the two eyes. Tho' fome of them exceed three inches in length, they occupy but a fmall fpace. When a butterfly is not in queft of food, the probofcis is rolled up in a fpiral form, fimilar to that of a watch-fpring, each fucceffive ring covering the one which precedes. The fubftance of the probofcis has fome refemblance to that of horn. It tapers from the bafe to the extremity. It is compofed of two fimilar and equal parts, each of which is concave, and, when joined, form three diftinct tubes. Reaumur has rendered it probable, that thefe tubes enable the animals to extract the juices of plants, to conduct air into their bodies, and to convey the fenfation of fmelling. Hence, the probofcis of infects is an inftrument which ferves them for a mouth, a nofe, and a wind-pipe.

The upper part of the trunk or body of infects is called the thorax, and the under part the abdomen, or belly. The abdomen contains the ftomach, and other vifcera. It confifts of feveral rings, or fegments, and is perforated with fpiracula, or tubes, which fupply the want of lungs. The abdomen is terminated by the tail, which, in fome infects, is armed with a fting, a forceps, a briftle, or a kind of a claw with a moveable thumb.

The legs are compofed of three parts, connected to each other by joints, and reprefent the thighs, fhanks, ankles, and feet of larger animals.

The wings of infects are fo diverfified in number, confiftence and colour, that Linnæus has made them the foundation of the feveral orders or divifions into which he divides this numerous clafs of animals. Some infects

are furnished with four, and others two wings, and some of them are entirely destitute of these instruments of motion.

The four-winged insects are arranged in five orders. The *first* order Linnæus distinguishes by the name of *coleoptera*, or those insects whose upper pair of wings, consist of a hard, crustaceous, or horney substance. These cover and defend the under pair, which are of a more soft and flexible texture. This order comprehends the whole of what is properly called *scarabæi*, or the beetle tribe. Like other winged insects, all the beetles live for some time in the form of caterpillars, or grubs.

As a farther confirmation of the connection of manners with form and structure, it is here worthy of remark, that the same animals, when in the state of caterpillars, live in a different manner, and feed on substances of a very different kind from those they consume after their transformation into flies. The caterpillars of the garden-beetle, cock-chafer, &c. lead a solitary life under ground, and consume the roots of plants. Those of others feed upon putrid carcases, every kind of flesh, dried skins, rotten wood, the dung of men, and quadrupeds, and the small insects called *pucerons*, or *vine-fretters*. The devourers of the puceron contribute to cure such plants as happen to be infected with the *phthiriasis*, or lousy disease. But, after their transformation into flies, many of the same animals, which formerly fed upon dung and putrid carcases, are nourished with the purest nectareous juices extracted from fruits and flowers. The creatures themselves, with regard to what may be termed *individual animation*, have suffered no alteration. But, the fabrick of their bodies, their instruments of motion, and the organs by which they take their food, are materially changed. The change of structure, though the animals retain their identity, produces the greatest diversity in their manners, their œconomy, and the powers of their bodies. In the caterpillar-state, these animals are extremely voracious, and, in many instances, acquire a greater magnitude than they possess after transformation: but they are incapable of multiplying their species,

ſpecies, and of receiving nouriſhment from the ſame kinds of food. Beſides, many caterpillars, previous to their transformation, live even in a different element. The ephemeron fly, when in the caterpillar ſtate, lives no leſs than three years in the water, and extracts its nouriſhment from earth and clay. After transformation, this animal ſeldom exiſts longer than one day, during which the ſpecies is propagated, and myriads of eggs are depoſited on the ſurface of the water. Theſe eggs produce worms, or caterpillars, and the ſame proceſs goes perpetually round.

Linnæus's *ſecond* order of inſects, or *hemiptera*, have likewiſe four wings. But, the upper pair, inſtead of being hard and horny, rather reſemble fine vellum. They cover the body horizontally, and do not meet in a direct line, forming a ridge, or ſuture, as in the beetle tribe. The whole of this order are furniſhed with a proboſcis or trunk for extracting their food.

This order comprehends ſeveral genera or kinds, ſome of which we ſhall mention in a curſory manner.—The *blatta, or cockroach*, is an animal which avoids the light, and is particularly fond of meal, bread, putrid bodies, and the roots of plants. It frequents bakers ſhops and cellars, and flies the approach of danger with great ſwiftneſs.—The head of the *mantis*, or *camel-cricket*, appears, from its continual nodding motion, to be ſlightly attached to the thorax. This inſect is regarded by the Africans as a ſacred animal; becauſe it frequently aſſumes a praying or ſupplicating poſture, by reſting on its hind feet, and elevating and folding the firſt pair.—The *gryllus* comprehends a number of ſpecies, ſome of which are called *graſshoppers*, others *locuſts*, and others *crickets*. The *larvæ* or caterpillars of the grylli, have a great reſemblance to the perfect inſects, and, in general, live under ground. Many of theſe inſects feed upon the leaves of plants. Others, which live in houſes, prefer bread, and every kind of farinaceous ſubſtance. The *fulgora*, or fire-fly: The foreheads of ſeveral of this genus, eſpecially of thoſe that inhabit China, and other hot climates, emit a very lively ſhining light during the night, which often alarms thoſe

who are unacquainted with the cauſe of the appearance. The *cicada*, *frog-hopper*, or *flea-locuſt*: The *larvæ*, or caterpillars, of ſome of this genus, diſcharge a kind of froth or ſaliva from the anus and pores of the body, under which they conceal themſelves from the rapacity of birds, and other enemies.—The *papa*, or *water ſcorpion*, frequents ſtagnant waters. It lives chiefly on aquatic inſects, and is exceedingly voracious.—The *cimex* or bug: Many ſpecies of this genus feed upon the juices of plants, and others upon the blood of animals. Some of them are found in waters, and others frequent houſes, among which, though it wants wings, is the bed-bug, a peſtiferous inſect, which is too well known, and too generally diffuſed. The bugs differ from other inſects by their ſoftneſs; and moſt of them emit a very fœtid ſmell.—The *aphis*, *puceron*, or *vine-fretter*: Theſe inſects are very common, and are generally termed the *lice* of the plants which they infeſt: The puceron, as remarked in the firſt chapter, is viviparous in ſummer, and oviparous in autumn. Numbers of them are devoured by the ants, on account, as is ſuppoſed, of a ſweet liquor with which their bodies are perpetually moiſtened.—*Chermes*: The *larvæ* or caterpillars of this inſect have ſix feet, and are generally covered with a hairy or woolly ſubſtance. The winged inſects leap or ſpring with great agility, and infeſt a number of different trees and plants: The females, by means of a tube at the termination of their bodies, inſert their eggs under the ſurface of the leaves, and the worms, when hatched, give riſe to thoſe tubercles, or galls, with which the leaves of the aſh, the fir, and other trees, are ſometimes almoſt entirely covered.

The *third* order or tribe of four-winged inſects conſiſts of three genera only. But, the ſpecies comprehended under them are exceedingly numerous. All butterflies and moths belong to this order. Their wings are covered with a farinaceous powder, or rather with a kind of ſcales or feathers, diſpoſed in regular rows, nearly in the ſame manner as tiles are laid upon the roofs of houſes. The elegance, the beauty, the variety of colours exhibited in their wings, are produced by the diſpoſition and different tinc-

tures of theſe minute feathers. The inſects of this order, on account of their beauty and eaſy preſervation, have always been the favourites of collectors, and particularly of thoſe of the female ſex. When the feathers are rubbed off, the wings appear to be nothing more than a naked, and often a tranſparent, membrane. The feelers of the *papilio*, or *butterfly*, are thickeſt at their extremity, and often terminate in a kind of capitulum, or head. Their wings, when ſitting, or at reſt, are erect, their extremities join each other above the body, and the animals fly about, in queſt of food and of their mates, during the day.—The *moths* are divided into two genera, the one called *ſphinx*, or *hawk-moth*, and the other *phalæna*, or *moth*. The feelers of the *ſphinx* are thicker in the middle than at the extremities, and their form, in ſome meauſure, reſembles that of a priſm. The wings are, in general, deflected, their outer margins declining toward the ſides. They fly about early in the morning, and after ſun-ſet; and, by means of their proboſcis, like the butterflies, they ſuck the juices of plants.—The *phalæna* or *moth*: The feelers of this genus are ſetaceous, and taper from the baſe to the point. When at reſt, their wings are commonly deflected; and they fly during the night. Previous to their transformation, the caterpillars of the whole of this genus ſpin webs for covering and protecting the animals while in the chryſalis ſtate. From a ſpecies of this tribe mankind have derived one of the greateſt articles of luxury and of commerce which now exiſts in the world. That ſeemingly contemptible, that diſguſting reptile known by the appellation of the *ſilk-worm*, in its paſſage from the caterpillar to the chryſalis ſtate, produces thoſe ſplendid materials which adorn the thrones of Princes, and add dignity and luſtre to female beauty*.

The wings of the *fourth* order, diſtinguiſhed by the name of *neuroptera*, are membranaceous, naked, and ſo interſperſed with delicate veins, that they have the appearance of beautiful net-work. Their tail has no ſting; but that of the male is frequently furniſhed with a kind of forceps or pincers. To this order belongs the *libella*,† or

* See Chap. XI. concerning the transformation of Animals. S.

† Libellula.

or *dragon-fly*, an inſect of very ſplendid and variegated colours. It is a large and well known fly, and frequents rivers, lakes, pools, and ſtagnating waters, in which the females depoſit their eggs. Their mode of generating is ſingular. Different ſpecies of them appear from the beginning of ſummer to the middle of autumn. They generally fly in pairs, and in a ſtraight line, the male purſuing the female. The organs of the male are ſituated in his breaſt: When he overtakes her, with the forceps in his tail he lays hold of her by the neck, while ſhe, by an inſtinctive impulſe, makes the lower end of her body approach the male organs. In this united ſituation they form a kind of ring, have the appearance of a double animal, and fly along till the purpoſe is accompliſhed. Under the ſame order is comprehended the *phryganea*, or *ſpring-fly*: The larvæ or caterpillars of this genus live in the water, and are covered with a ſilken tube. They have a very ſingular aſpect; for, by means of a gluten, they attach to the tubes in which they are incloſed ſmall pieces of wood, ſand, gravel, leaves of plants, and not unfrequently live teſtaceous animals, all of which they drag along with them. They are very commonly found in ſalads of the water-creſs; and, as they are often entirely covered with green leaves, they have the appearance of animated plants. They are in great requeſt among fiſhermen, by whom they are diſtinguiſhed by the name of *ſtone*, or *cod-bait*. The fly, or perfect inſect, frequents running waters, in which the females depoſit their eggs.

The *fifth* order is termed *hymenoptera*. In general, the inſects belonging to this order have four membranaceous and naked wings. In ſome of the genera, however, the neuters, and, in others, the males, or even the females, have no wings. Their tails, except in the male ſex, are armed with a ſting.—The female of the *cynips*, an inſect belonging to this order, inſerts her eggs into the leaves of the oak, and the caterpillars produced from them give riſe to the galls employed in the compoſition of ink.—This order likewiſe includes the waſp, the bee, and the ant. Many of the waſp kind, like the bees, live in ſociety, make combs in which the females depoſit their

egg ,

eggs, and feed their caterpillars with an inferior ſpecies of honey. Others of them conſtruct a ſeparate neſt for each individual egg.—The bee is an inſect too well known to require a particular deſcription. The males have no ſting; but the females, and the drones, or neuters, have a very ſharp pointed ſting concealed in their abdomen. The female of the honey-bee is much larger than the male, or the neuter. Her feelers contain fifteen articulations. Her abdomen is compoſed of ſeven ſegments, and is much longer than her wings. The feelers of the male contain only eleven articulations. The neuters are much ſmaller than the males or females, and their feelers conſiſt of fifteen articulations.—The ſting, with which the male and female *ants* are armed, is concealed within the abdomen. The males and females of the ant are furniſhed with wings, but the neuters are deprived of theſe inſtruments of motion. The ants live in ſocieties which are compoſed of males, females, and neuters. The males are much ſmaller than the females and neuters. Soon after the males and females propagate the ſpecies, they all die. Some of the neuters, however, ſurvive the winter; but they remain in their habitation without movement, or diſcovering any ſigns of life. From theſe circumſtances in the hiſtory of ants, it is apparent, that the induſtry and ſagacity ſo long and ſo univerſally aſcribed to theſe little animals could be of no uſe either to themſelves or their progeny. The female, after depoſiting her eggs, takes no farther care of her offspring. But, what is ſingular, the important office of feeding the *larvæ*, or caterpillars, after the eggs are hatched, is left entirely to the neuters. This affectionate and aſſiduous attention of the neuters to a progeny neither begot nor brought forth by them, is ſo aſtoniſhing, ſo contrary to the general œconomy of Nature, that no reaſoning or theory can account for a fact ſo uncommon, till farther diſcoveries ſhall be made in the hiſtory of theſe ſurpriſing animals. What is ſtill more ſingular, after the caterpillars are transformed into the chryſalis ſtate, the neuters are inceſſantly and anxiouſly employed in preſerving the chryſales from humidity when the weather is wet, and in expoſing them to the warmth of the

ſun

ſun when it is fair. Theſe chryſales are larger than the animals themſelves, and yet they carry them off with eaſe and rapidity.

The *ſixth* order of inſects is termed *diptera*, or two-winged inſects. The different ſpecies of this order, beſide wings, are furniſhed with what is called a *halter* or a *poiſer*, which is ſituated under each wing, and is terminated by a *capitulum*, or knob. This order comprehends ten genera, and a multitude of ſpecies. The caterpillars of the *oeſtrus*, or *gad-fly*, lie concealed in the ſkins of cattle, where they are nouriſhed during the whole winter. The perfect inſects are frequent wherever horſes, cows or ſheep are grazing. Some of them depoſit their eggs in the ſkins of cows or oxen; others depoſit them in the inteſtines of horſes, to which they get acceſs by the anus; and others in the noſtrils of ſheep. In theſe habitations, the caterpillars reſide till they are full grown, when they throw themſelves down to the earth, and generally paſs the chryſalis ſtate under the firſt ſtone they meet with. —The *muſca*, or common *fly*: The mouth of this inſect conſiſts of a ſoft, fleſhy proboſcis, with two lateral lips. The caterpillars of ſome of this genus devour the pucerons; others conſume all kinds of putrid fleſh; others are found in cheeſe; others in the excrements of different animals; and many of them live in the water, and prefer that which is moſt corrupted and muddy.—The mouth of the *culex*, or *gnat*, conſiſts of a flexible ſheath, incloſing four briſtles, or pointed ſtings. The feelers of the female gnat are plain like a thread; but thoſe of the male are beautifully feathered. The worms, or caterpillars, of this genus are commonly found in ſtagnant waters. The gnats generally frequent woods and marſhy places. The females, in particular, are very troubleſome, and ſting ſeverely.—The feet of the *hippoboſca*, or *horſe-fly*, are armed with a number of nails, or crotchets. In ſome ſpecies, the wings croſs each other; in others, they are open. The horſe-flies frequent woods and marſhy grounds, and are extremely incommodious to birds and quadrupeds, whoſe blood is the only food of theſe inſects.

The *ſeventh* order of inſects Linnæus denominates *aptera*,

tera, becauſe neither males nor females are furniſhed with wings. This order comprehends thirteen genera, and a great number of ſpecies, many of which are very offenſive and noxious to the human ſpecies. The *pediculus*, or *louſe*, has ſix legs, two prominent eyes, and its mouth contains a ſting or ſucker, by which it extracts blood and other juices from the bodies of animals. Though almoſt every different animal is infeſted with a peculiar ſpecies of lice, the ſpecific characters of very few of them have hitherto been aſcertained. Lice are of various forms. Some of them are oval, others oblong, and others long and ſlender. They are oviparous animals, and their eggs are large in proportion to the ſize of their bodies. Before they arrive at maturity, they change their ſkin ſeveral times. They are ſuppoſed to be hermaphrodites. This circumſtance, if true, may partly account for their prodigious multiplication. Swammerdam, who diſſected a great number, aſſures us, that he never found one without an ovary, nor even diſcovered the organs peculiar to the male ſex. If this ſtructure be univerſal, the louſe is an hermaphrodite of a very peculiar kind; becauſe it muſt be capable of fœcundating itſelf. Several ſpecies of worms are hermaphrodites; but, inſtead of fœcundating themſelves, they are obliged to impregnate each other.—The *pulex*, or *flea*, has likewiſe ſix legs, the articulations of which are ſo exceedingly elaſtic, that the animal is enabled, by their means, to ſpring to ſurpriſing diſtances. It has two fine eyes, and its body is covered with cruſtaceous ſcales. The flea is the only inſect belonging to this order which undergoes a transformation ſimilar to that of the former orders: All the other wingleſs inſects are produced in a perfect ſtate either by the mother, or from eggs. The caterpillars of the flea have forked tails, and are very ſmall and lively. They may be nouriſhed in boxes, and fed with flies, which they greedily devour. Before changing into the chryſalis ſtate, they live fourteen or fifteen days in the form of caterpillars.—*Aranea*, or ſpider: This genus comprehends a great many ſpecies. The ſpider has eight feet, and an equal number of immoveable eyes. The chief prey of the

the ſpider is flies, animals whoſe motions are extremely quick and deſultory. To enable the ſpider to obſerve their movements in every direction, ſhe is furniſhed with eight eyes, the poſition of which merits attention: Two of them are placed on the top of the head, other two on the front, and two on each ſide. The mouth is armed with two crotchets, by which it ſeizes and kills its prey. Round the anus there are ſeveral muſcular inſtruments, ſhaped like nipples or teats. Each of theſe contain about a thouſand tubes or outlets for threads ſo extremely minute, that many hundreds of them muſt be united before they form one of thoſe viſible ropes of which the ſpider's web is compoſed. The figure of the web varies according to the ſpecies, or the ſituation the animal chooſes for its abode. After the web is completed, ſome ſpecies reſide in the center, and others occupy the extremity of their habitations, where they lie in ambuſh, with aſtoniſhing patience, till an ill-fated fly is accidentally entangled. The ſpider, from the vibration of the threads, perceives his prey, ruſhes forth from his cell, inſtantly ſeizes it with his fangs, devours its vitals, and afterwards rejects the exhauſted carcaſe. Spiders prey upon all weaker inſects, and even upon their own ſpecies.—The *ſcorpion:* This venomous inſect is a native of warmer climates than thoſe of the north of Europe. It has eight feet, and two claws, the laſt of which are ſituated on the fore part of the head. Like the ſpider, the ſcorpion has eight eyes, three of which are placed on each ſide of the breaſt, and the other two on the back. The tail is long, jointed, and terminates in a ſharp crooked ſting. The venom of the ſcorpion is more deſtructive than that of any other inſect; and is ſometimes fatal in Africa, and other hot regions.

The *laſt* diviſion of inſects is termed *vermes*, or *worms*, by Linnæus. This claſs comprehends not only all the inſects commonly called *worms*, but all the teſtaceous animals, and the zoophites, or plant-animals. The ſtructure of ſeveral genera belonging to this claſs is extremely ſingular. After giving a few examples, we ſhall haſten to the concluſion of the preſent ſubject.

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The body of the *gordius*, or *hair-worm*, is long, ſhaped like a thread or hair, ſmooth, and round. A ſpecies of the hair-worm is very common in our freſh waters, and is perfectly harmleſs. In Scotland, it is a vulgar and fooliſh notion, that the hair of a horſe's tail, when thrown into the water, is converted into this worm*. Though inoffenſive in this country, the hair-worm of Africa, and of both the Indies, is extremely noxious. It is of a pale yellowiſh colour, and is frequently met with among the graſs, eſpecially when covered with dew. It often inſinuates itſelf into the naked feet or limbs of children and unwary perſons, where it produces an inflammation, which is ſometimes fatal. It may be extracted by tying a thread round its head, and then pulling it gently out of its abode. But, this operation requires great caution; for, if the animal is broken, the part which remains does not die, but, in a ſhort time, regains what it had loſt, and becomes equally entire and troubleſome as if it had received no injury.—The *lumbricus*, or *earth-worm:* The body of this worm is cylindrical, conſiſts of many rings, and the middle is encompaſſed with an elevated belt. It is likewiſe furniſhed with ſharp prickles, which the animal can erect or depreſs at pleaſure. Through certain perforations in the ſkin, it occaſionally emits a ſlimy fluid, which lubricates its body, and facilitates its paſſage into the ſoil. The inteſtines of this worm are always filled with a fine earth, which ſeems to conſtitute its only nouriſhment. Earth-worms, like ſnails, are hermaphrodite. The parts of generation are placed near the neck, and they mutually impregnate each other. This operation is performed on the ſurface of the ground; and, while thus employed, they will allow themſelves to be cruſhed to pieces rather than part. The females depoſit their eggs in the earth, where they are hatched. Theſe worms, like the polypus, when cut through the middle, reproduce, and each portion becomes a diſtinct individual. According to the different periods of their growth, their colour varies; but, in general, it is a duſky red.

The *ſepia*, or *cuttle-fiſh*, though comparatively a large

animal,

* A ſimilar notion very generally prevails in theſe United-States.

animal, ſome of them being two feet long, is ranked by Linnæus under the claſs of *worms*. The ſtructure of the cuttle-fiſh is remarkable. Its body is cylindrical, and, in ſome of the ſpecies, is entirely covered with a fleſhy ſheath; in others, the ſheath reaches only to the middle of the body. The ſepia has eight tentacula, or arms, beſide two feelers, as they are called, which are much longer than the arms. Both the feelers and arms are furniſhed with ſtrong cups, or ſuckers, ſhaped like the cup of an acorn, by means of which the animal ſeizes its prey, and firmly attaches itſelf to rocks, or to the bottom of the ſea. It has two large and prominent eyes. What is ſtill more ſingular, it is furniſhed with a hard, ſtrong, horny beak, preciſely ſimilar, both in texture and ſubſtance, to the bill of a parrot. With this bill, the cuttle-fiſh is enabled to break the ſhells of limpets, and other ſhell-animals, upon which it chiefly feeds. In the belly, there is an aperture through which the animal, when purſued by its enemies, emits a fluid as black as ink, tinges the water, and often eſcapes by this ingenious ſtratagem. The ancient Romans frequently uſed this black fluid as ink in writing. The males and females copulate by a mutual embrace. The female depoſits her eggs upon ſea-plants in parcels reſembling bunches of grapes. At the inſtant they drop from the mother, the eggs are white; but the male immediately coats them over with a black liquor. The male perpetually accompanies the female. When the female is attacked, he braves every danger, and often reſcues her at the hazard of his own life. The bone of the cuttle-fiſh is very light, and, when pulverized, it is employed by different artiſts in making moulds.

The *meduſa* is an animal which has the appearance of a lifeleſs maſs of jelly floating on the ſurface of the ocean. Its body is roundiſh, flattened underneath, and the mouth is ſituated in the center of the under part. There are many ſpecies of this ſeemingly moſt imperfect, defenceleſs, and abject part of animated nature. They are, however, furniſhed with tentacula, by which they ſeize inſects and the ſmall fry fiſhes, convey them to their mouths, and devour

devour them. Although the ſport of the waves, and the prey of every fiſh that approaches them, they are gregarious animals, and, particularly in warm climates, ſometimes collect in ſuch numbers as to have the appearance of whitiſh rocks under the ſurface of the ocean.

We have thus given a ſhort ſketch of the ſtructure of animals, from man down to the inſect tribes, and ſhall now conclude with a few remarks.

In all the variety of animated beings whoſe general ſtructure has been exhibited, the intelligent reader will eaſily perceive, that the bodily forms of the different kinds are exactly adapted to the rank they hold in the creation, and that their œconomy and manners are ſtrictly and invariably connected with their ſtructure and organs. If a new animal appears, and if its figure be uncommon, it may with ſafety be pronounced, that its manners are equally uncommon. Change the external or internal form of an animal; diminiſh the number of ſtomachs in the ruminating tribes; or give to the horſe a parrot's bill; and the ſpecies will be annihilated.

The comparative power, or ſtrength, of animals depends not on ſtructure alone. Mental faculties and docility, or the capacity of receiving inſtruction, ſeem to be the greateſt ſources of animal power. Hence man's unlimited empire over all other creatures. The inventions of language, of arms, of writing, printing, and engraving, have been the chief means of extending his influence, and of his acquiring the dominion of the earth. By theſe arts, men tranſmit the improvements, the inventions, and the acquiſitions, of one age to another. By theſe arts, the diſpoſitions of men are ſoftened, their manners become more and more civilized, humanity is gradually extended and refined, and the groſſer animoſities yield to external politeneſs and decorum at leaſt, if the feelings themſelves be not blunted. How far this progreſs of ſcience, and the peaceful arts of life, by the accumulation of ages, may proceed, it is impoſſible to determine. But, the

the time, it is to be hoped, is not very remote, when the fiercer contentions of nations will ceaſe, when ſelfiſhneſs and venality, which at preſent ſeem to be inſeparable from commercial ſtates, will give way to generoſity of temper, and uprightneſs of conduct.

CHAP. III.

Of the Reſpiration of Animals—Air neceſſary to the exiſtence of all animated beings—The various modifications of the organs employed by Nature for the tranſmiſſion of Air into animal bodies.

IT is foreign to the deſign of this chapter to mention the different kinds of air; to unfold its compoſition; or to recapitulate the innumerable benefits derived from it in the animal and vegetable kingdoms, in the arts of life, and in the texture and coheſion of inanimate bodies. For our purpoſe, it is ſufficient to obſerve, that by *air* is meant that common elaſtic fluid which pervades this globe, and which by its weight, its preſſure in all directions, and its compreſſibility, inſinuates itſelf into every vacuity, and is neceſſary to the exiſtence of every animal and vegetable being.

In man, and the larger land-animals, air is taken into the body by the lungs. When an animal inſpires, the external air paſſes through the apertures of the mouth and noſe into the trachea, or wind-pipe, and thence directly into the lungs. This air, by inſinuating itſelf into the numerous cells of the lungs, neceſſarily inflates them, and, when retained for a ſecond or two, produces an uneaſy ſenſation. To remove this diſagreeable feeling, the animal inſtinctively, by the exertion of particular muſcles deſtined by Nature for that purpoſe, forces out the air, and thus removes the offending cauſe. The lungs, after the

the air is thrown out, inftead of being inflated, collapfe; and, if a frefh fupply is not foon taken in, a fimilar uneafy fenfation is felt, which obliges the animal again to infpire. This alternate reception and rejection of air goes on during the life of the animal, and is diftinguifhed by the general name of *refpiration*. But, when treating more accurately of the fubject, the act of taking air into the lungs is called *infpiration*, and the act of throwing it out is termed *expiration*.

That the refpiration of air is indifpenfible to the exiftence of land-animals, has been proved by innumerable experiments made with the air-pump. Mice, rats, rabbits, cats, dogs, &c. when placed in an exhaufted receiver, inftantly become reftlefs, and difcover fymptoms of pain. Their bodies fwell, and their life is foon extinguifhed. Indeed, our own feelings are fufficient to afcertain this fact. No perfon can remain long either in a ftate of infpiration or expiration without being fuffocated.

But, the alternate motions of infpiration and expiration, joined to the circulation of the blood through the lungs, may be confidered as the more mechanical effects of refpiration. Though thefe operations are abfolutely neceffary to the exiftence of animals, yet the air itfelf has been fuppofed to impart fome vital principle to the blood, without which life could not be continued.

The ingenious Doctor Crawford, in his treatife on Animal Heat, has rendered it probable, that the refpiration of air is the caufe of that vital warmth without which no animal can exift. After mentioning a well known fact, that all bodies, whether animate or inanimate, contain a certain quantity of fire as a principle in their compofition, the Doctor remarks, that this quantity, in different bodies, varies according to their nature or texture; that this fire, when in a latent or quiefcent ftate, is termed *abfolute heat*; that, when fubftances of different textures have a given quantity of heat thrown into them, their temperature will be difcovered to be different by the thermometer; for the fame quantity of heat which raifes one body

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to a certain degree, will raiſe another to a greater or a leſs; and this different diſpoſition of bodies is called their capacity of containing abſolute heat.

Doctor Crawford next endeavours to prove by experiments, that, when phlogiſton is added to any body, its capacity of containing abſolute heat is diminiſhed; and that, when phlogiſton is abſtracted from the ſame body, its capacity of receiving abſolute heat is augmented. Hence he infers, that heat and phlogiſton ſeem to conſtitute two oppoſite principles in nature. By the action of heat upon bodies, the force of their attraction to phlogiſton is diminiſhed; and, by the action of phlogiſton, a part of the abſolute heat, which exiſts in every ſubſtance as an element, is expelled. 'Hence,' ſays the Doctor, 'animal heat ſeems to depend upon a proceſs ſimilar to a 'chemical elective attraction. The air is received into 'the lungs, containing a great quantity of abſolute heat. 'The blood is returned from the extremities, highly im'pregnated with phlogiſton. The attraction of the air 'to the phlogiſton is greater than that of the blood. This 'principle will therefore leave the blood to combine with 'the air. By the addition of the phlogiſton, the air is 'obliged to depoſit a part of its abſolute heat; and, as the 'capacity of the blood is, at the ſame moment, increaſed 'by the ſeparation of the phlogiſton, it will inſtantly unite 'with that portion of heat which had been detached from 'the air.

'We learn from Doctor Prieſtley's experiments with 'reſpect to reſpiration, that arterial blood has a ſtrong at'traction to phlogiſton: It will, conſequently, during the 'circulation, imbibe this principle from thoſe parts which 'retain it with the leaſt force, or from the putreſcent parts 'of the ſyſtem: And hence the venous blood, when it 'returns to the lungs, is found to be highly impregnated 'with phlogiſton. By this impregnation, its capacity for 'containing heat is diminiſhed. In proportion, therefore, 'as the blood, which had been dephlogiſticated by the 'proceſs of reſpiration, becomes again combined with 'phlogiſton, in the courſe of the circulation, it will gra-

'dually

'dually give out that heat which it had received in the 'lungs, and diffuſe it over the whole ſyſtem *.'

The Doctor afterwards proceeds to aſſign a reaſon why the heat of animals is always equal. 'As animals,' ſays he, 'are continually abſorbing heat from the air, if there 'were not a quantity of heat carried off, equal to that 'which is abſorbed, there would be an accumulation of 'it in the animal body. The evaporation from the ſur-'face, and the cooling power of the air, are the great 'cauſes which prevent this accumulation. And theſe are 'alternately increaſed and diminiſhed, in ſuch a manner 'as to produce an equal effect. When the cooling power 'of the air is diminiſhed by the ſummer heats, the eva-'poration from the ſurface is increaſed; and when, on 'the contrary, the cooling power of the air is increaſed 'by the winter colds, the evaporation from the ſurface is 'proportionally diminiſhed †.'

This theory, though not ſupported by mathematical evidence, is not only ingenious, but ſeems to make a nearer approach to truth than any that has hitherto been invented ‡.

Reſpiration, beſide being the probable cauſe of the equable continuation of heat in animals, produces many other ſalutary and uſeful effects in the œconomy of animated bodies. There is a moſt intimate connection between the act of reſpiring and the circulation of the blood. When reſpiration is, for a ſhort time, interrupted by the fumes of burning ſulphur, by mephitic air, or by remaining ſome minutes under water, the action of the heart ceaſes. But, in many caſes of this kind, the motion of the heart may, and frequently has been renewed, by blowing air into the lungs, and by the application of ſtimulating ſubſtances to different organs of the body. In perſons ſeemingly dead from a temporary ſuſpenſion of reſpiration, if the lungs can be excited to act, the motion of the heart inſtantly

* Crawford on Animal Heat, pag. 73. S. † Ibid. pag. 84. S.

‡ If the reader is deſirous of ſeeing ſome pertinent remarks on Doctor Crawford's Theory of Animal Heat, he may conſult Doctor Gardiner's *Obſervations on the Animal Oeconomy, and on the Cauſes and Cure of Diſeaſes*, an ingenious and uſeful performance, lately publiſhed, and which merits much more attention from Philoſophers and Phyſicians than it has hitherto received. S.

inſtantly commences, the circulation of the blood is reſtored, and life is recovered. This intimate connection between reſpiration and the action of the heart, is one of thoſe aſtoniſhing facts in the animal œconomy, the cauſes of which will perhaps forever elude the keeneſt reſearches of the human intellect. All we know is, that certain functions are indiſpenſible to the exiſtence of animals, and that, if any of them are ſuſpended for a few ſeconds, life is extinguiſhed; namely, the action of the brain and nerves, the circulation of the blood, reſpiration, and a probable reſult of reſpiration, animal heat. Theſe functions, from their importance in the ſyſtem, have received the appellation of *vital functions*. There are other functions of the body, called *natural*, which are no leſs neceſſary to life, as the digeſtion and concoction of aliment, the various ſecretions and excretions. But, they are diſtinguiſhed from the vital functions, becauſe ſome of them may be ſuſpended for a conſiderable time without materially injuring the body.

Reſpiration commences inſtantly after birth, and is inſtinctively continued during life. In the fœtus ſtate, as formerly mentioned*, reſpiration is unneceſſary, becauſe the circulation of the general maſs of blood is carried on through a different channel. In the act of inſpiration, we are conſcious of making a certain effort; but, in the act of expiration, we ſcarcely perceive any exertion whatever.

Beſide the circulation of the blood, and the continuation of the vital warmth, reſpiration gives riſe to many other important functions in the animal œconomy. All animals who reſpire, beſide a watery vapor, exhale great quantities of mephitic or corrupted effluvia, which, if retained in the lungs, or breathed by other animals, would ſoon prove fatal. The muſcles of reſpiration, of which we have the command, are employed in many other operations of the body, beſide the mere act of breathing air. All animals furniſhed with lungs expreſs their wants, their affections and averſions, their pleaſures and pains, either by words, or by ſounds peculiar to each ſpecies. Theſe different

* See above, page 67.

different ſounds are produced by ſtraitening or widening the glottis and wind-pipe, or, in general, the paſſage through which the air paſſes in reſpiration. The inferior animals are by this means enabled to expreſs themſelves, though not by articulate ſounds, in ſuch a manner as to be perfectly intelligible to every individual of a ſpecies. On man alone, Nature has beſtowed the faculty of ſpeaking, or of expreſſing his various feelings and ideas, by a regular, extenſive, and eſtabliſhed combination of articulate ſounds. To have extended this faculty to the brute creation, would not, it is probable, have been of any uſe to them; for, though ſome animals can be taught to articulate, yet, from a defect in their intellect, none of them ſeem to have any idea of the proper meaning of the words they utter. Speech is performed by a very various and complicated machinery. In ſpeaking, the tongue, the lips, the jaws, the whole palate, the noſe, the throat, together with the muſcles, bones, &c. of which theſe organs are compoſed, are all employed. This combination of organs we are taught to uſe when ſo young that we are hardly conſcious of the laborious taſk, and far leſs of the manner by which we pronounce different letters and words. The mode of pronouncing letters and words, however, may be learned by attentively obſerving the different organs employed by the ſpeaker. By this means we are enabled to correct various defects of ſpeech, and even to teach the dumb to ſpeak; for dumbneſs is ſeldom the effect of imperfection in the organs of ſpeech, but generally ariſes from a want of hearing; and it is impoſſible for deaf men to imitate ſounds which they never heard, except they be taught to uſe their organs by viſion and by touching.

When about to laugh, we make a very full inſpiration, which is ſucceeded by frequent, interrupted and ſonorous expirations. When the titillation is great, whether it ariſes from the mind or body, theſe convulſive expirations ſometimes interrupt the breathing to ſuch a degree as to endanger ſuffocation. Moderate laughing, on the contrary, promotes health: By agitating the whole body, it quickens the circulation of the blood, gives an inex-

preſſible chearfulneſs to the countenance, and baniſhes every kind of anxiety from the mind.

In weeping, we employ nearly the ſame organs as in laughing. It commences with a deep inſpiration, which is ſucceeded by ſhort, broken, ſonorous, and diſagreeable expirations. The countenance has a diſmal aſpect, and tears are poured out. Weeping originates from grief, or other painful ſenſations either of body or mind: When full vent is given to tears, grief is greatly alleviated. Both laughing and weeping have been reckoned peculiar to man. But this notion ſeems not to be well founded. Though the other animals expreſs not their pleaſures or pains in the ſame manner as we do, yet all of them exhibit their pleaſant or painful feelings by ſymptoms or cries, which are perfectly underſtood by the individuals of each ſpecies, and, in many inſtances, by man. A dog, when hurt, complains in the bittereſt terms; and, when he is afraid, or perhaps melancholy, he expreſſes the ſituation of his mind by the moſt deplorable howlings. A bird, when ſick, ceaſes to ſing, droops the wing, abſtains from food, aſſumes a lurid aſpect, utters melancholy, weak cries, and exhibits every mark of depreſſed ſpirits. By this means, animals intimate the aſſiſtance they require, or ſoften thoſe who maltreat them. Their plaintive cries are ſometimes ſo affecting as to diſarm their enemies, or procure the aid of their equals. On the other hand, when animals are pleaſed or careſſed, they diſcover, by their countenance, by their voice, by their movements, unequivocal ſymptoms of chearfulneſs and alacrity of mind. Thus the expreſſions of pleaſure and pain by brute animals, though not uttered in the preciſe manner with thoſe of the human ſpecies, are perfectly analogous, and anſwer the ſame intentions of Nature.

By reſpiration, and the inſtruments employed in the performance of it, the larger animals are not only brought forth, but are enabled to extract milk from the breaſts of the mother. By reſpiration, odours are conveyed to the noſe; coughing, ſneezing, yawning, ſighing, ſinging,

vomiting,

vomiting, and many other functions in the animal œconomy, are at leaſt partly accompliſhed.

After this general view of the reſpiration of man and of quadrupeds, we proceed, according to the method laid down, to give ſome account of the ſame function in the other claſſes of animals.

With regard to BIRDS, though, like other land-animals, they reſpire by means of lungs, Nature has enabled them to tranſmit air to almoſt every part of their bodies. The lungs of birds are ſo firmly attached to the diaphragm, the ribs, the ſides, and the vertebræ, that they can admit of very little dilatation or contraction *. Inſtead of being impervious, the ſubſtance of the lungs, as well as of the diaphragm, to which they adhere, is perforated with many holes or paſſages for the tranſmiſſion of air to the other parts of the body †. To each of theſe perforations a diſtinct membranous bag is joined. Theſe bags are extremely thin and tranſparent. They extend through the whole of the abdomen, are attached to the back and ſides of that cavity, and each of them receives air from their reſpective openings into the lungs. The cells in birds which receive air from the lungs are found not only in the ſoft parts, but in the bones. That ingenious and accurate anatomiſt, Mr. John Hunter of London, remarks, that the bones of birds which receive air are of two kinds: ‘ Some, as the ſternum, ribs, and vertebræ, have their internal ſubſtance divided into innumerable cells, whilſt others, as the os humeri and the os femoris, are hollowed out into one large canal, with ſometimes a few bony columns running acroſs at the extremities. Bones of this kind may be diſtinguiſhed from thoſe that do not receive air by certain marks: 1. By

* Theſe numerous adheſions of the lungs of birds, and the ſmall dilatation of the thorax in the act of inſpiration, are ſuppoſed, by an ingenious and learned modern Phyſiologiſt and Naturaliſt, to be the reaſon why, in this extenſive claſs of animals, the brain is not ſubjected to that alternate riſing and falling which is obſerved in the whole claſs of *mammalia*, during inſpiration and expiration. See the beautiful paper of Mr. Blumenbach, entitled *Specimen Phyſiologiæ comparatæ inter animantia calidi Sanguinis Vivipara et Ovipara*, publiſhed in the ninth volume of the *Commentationes Societatis Regiæ Scientiarum Gottingenſis*, for the years 1787, and 1788.

† This fact ſeems to have been firſt mentioned by the celebrated Doctor Harvey. See Harvey de Generat. Animal. Exercit. 3. S.

'1. By their lefs fpecific gravity: 2. By being lefs vaf-'cular, and therefore whiter: 3. By their containing 'little or no oil, and confequently being more eafily 'cleaned; and, when cleaned, appearing much whiter 'than common bones: 4. By having no marrow, or even 'any bloody pulpy fubftance in their cells: 5. By not 'being, in general, fo hard and firm as other bones; 'and, 6. By the paffage that allows the air to enter the 'bones, which can eafily be perceived. In the recent 'bone we may readily difcover holes, or openings, not 'filled with any fuch foft fubftance as blood-veffels, or 'nerves; and it happens that feveral of thefe holes are 'placed together, near that end of the bone which is 'next to the trunk of the bird; and are diftinguifhable 'by having their external edges rounded off; which is 'not the cafe with the holes through which either nerves 'or blood-veffels pafs into the fubftance of the bone *.'

Mr Hunter afterwards informs us, that the lungs, at the anterior part, open into a number of membranous cells, which lie upon the fides of the pericardium, and communicate with thofe of the fternum. At the fuperior part, the lungs open into the large cells of a loofe net-work, through which the wind-pipe, gullet, and large veffels, pafs as they proceed to and from the heart. Thefe cells, when diftended with air, augment confiderably the part where they are fituated; and this augmentation, or fwelling, is generally a mark either of anger or of love. This tumefaction is remarkable in the turkey-cock, in the pouting-pigeon, and in the breaft of a goofe when fhe cackles. Thefe cells communicate with others in the axilla, under the large pectoral mufcle. In moft birds, the axillary cells communicate with the cavity of the os humeri by fmall openings in the hollow furface near the head of that bone. In fome birds, thefe cells are continued down the wing, and communicate with the ulna and radius; in others, they extend even to the pinions. The pofterior edges of the lungs open into the cells of the vertebræ, into thofe of the ribs, the canal of the fpinal marrow, the facrum, and other bones of the pelvis;

* Hunter's Obfervations on certain parts of the Animal Oeconomy, pag. 79. S.

vis; from these parts the air finds a passage into the thigh-bone. 'Thus,' continues our learned and indefatigable author, 'the cells of the abdomen, those surrounding the 'pericardium, those situated at the lower and forepart of 'the neck, and in the axilla, those in the cellular membrane under the pectoral muscles, as well as in that 'which unites the skin to the body, all communicate 'with the lungs, and are capable of being filled with air; 'and again from these the cells of the sternum, ribs, 'vertebræ of the back and loins, bones of the pelvis, 'the humeri, the ulna and radius, with the pinions and 'thigh-bones, can in many birds be furnished with air*.'

These facts, which our author candidly acknowledges had been formerly observed, led him, in the year 1758, to make experiments on the breathing of birds, in order to prove the free communication between the lungs and the several parts of the body mentioned above.

'First,' says he, 'I made an opening into the belly of a 'cock, and having introduced a silver canula, tied up 'the trachea; I found that the animal breathed by this 'opening, and might have lived; but, by an inflamma-'tion in the bowels coming on, adhesions were produced, 'and the communication cut off.

'I next cut the wing through the os humeri, in ano-'ther fowl, and tying up the trachea, as in the cock, 'found that the air passed to and from the lungs by the 'canal in this bone. The same experiment was made 'with the os femoris of a young hawk, and was attended 'with nearly the like success †.'

The extreme singularity of this almost-universal diffusion of air through the bodies of birds, naturally excited a desire to discover what might be the intention of Nature in producing a structure so extraordinary. Mr Hunter first imagined that it might be intended to assist the act of flying ‡, by increasing the volume and strength of the animal, without adding to its weight, which must be diminished;

* Hunter's Observations on certain parts of the Animal Oeconomy, p. 81. S.

† Ibid. p. 82. S.

‡ This was likewise the opinion of the late learned Professor Camper. See what he has said on this curious subject, in the fourth volume of the *Hedendaegze letter oeffeningen*, n. 2. for the year 1771.

minifhed; becaufe the fpecific gravity of the external air is fuperior to that of the internal air, which is rendered more rare by the heat of the animal's body. This opinion was corroborated, by confidering that the feathers of birds, and particularly thofe of the wings, contain a great quantity of air. With his ufual ingenuoufnefs, however, Mr. Hunter, in oppofition to his firft conjecture, informs us, that the oftrich, which does not fly, was amply provided with air-cells difperfed through its body *; that the wood-cock, and fome other flying birds, were not fo liberally fupplied with thefe cells as the oftrich; and that the bat had no fuch peculiarity of ftructure. With regard to the oftrich, though it is not intended to fly, it runs with amazing rapidity, and, confequently, requires fimilar refources of air.

He next conjectured, from analogy, that the air-cells in birds ought to be confidered as an appendage to the lungs; becaufe in the fnake, viper, and feveral other amphibious animals, the lungs are continued, in the form of two bags, through the whole abdomen, the upper part of which can only perform the office of refpiration with any degree of effect; becaufe the lower part has comparatively few air-veffels. 'The air,' fays Mr. Hunter, 'muft pafs through this upper part before it gets to 'the lower in infpiration, and muft alfo repafs in expira- 'tion; fo that the refpiratory furface has more air appli- 'ed to it than what the lungs of themfelves could contain. 'There is, in fact, a great fimilarity between birds and 'that clafs of animals called *amphibious*; and, although a 'bird and a fnake are not the fame in the conftruction of the 'refpiratory organs, yet the circumftance of the air paf- 'fing in both beyond the lungs, into the cavity of the 'abdomen, naturally leads us to fuppofe, that a ftructure 'fo fimilar is defigned in each to anfwer a fimilar pur- 'pofe. This analogy is ftill farther fupported by the 'lungs in both confifting of large cells. Now, in am- 'phibious animals, the ufe of fuch a conformation of lungs 'is

* Profeffor Camper informs us, that in the oftrich, and in the cafowary, which is a fpecies of the oftrich, the air does not penetrate into the offa humeri; but that it is prefent in all the other bones.

'is evident; for it is in consequence of this structure that 'they require to breathe less frequently than others. 'Even considering the matter in this light, it may still, 'in birds, have some connection with flying, as that mo-'tion may easily be imagined to render frequency of re-'spiration inconvenient, and a reservoir of air may 'therefore become singularly useful. Although we are 'not to consider this structure in birds to be an extension 'of lungs, yet I can easily conceive this accumulation of 'air to be of great use in respiration; for, as we observed 'in the viper, that the air, in its passage to and from 'these cells, must certainly have a considerable effect upon 'the blood in the lungs, by allowing a much greater 'quantity of air to pass in a given time, than if there 'was no such construction of parts. And this opinion 'will not appear to be ill founded, if we consider, that, 'both in the bird and the viper, the surface of the lungs 'is small in comparison to what it is in many other ani-'mals which have not this extension of cavity.—We must 'not, however, give up the idea of such structure being 'of use in flying; for I believe we may set it down as a 'general rule, that, in the birds of longest and highest 'flight, as eagles, this extension, or diffusion of air, is 'carried farther than in the others; and this opinion is 'strengthened, by comparing this structure with the re-'spiratory organs in the flying insects, which are com-'posed of cells diffused through the whole body; and 'these are extended even into the head and down the 'extremities, while there is no such structure in those 'that do not fly, as the spider,' &c.

Though Mr. Hunter's modesty has not permitted him to draw his conclusion in a positive manner, he seems to have proved decidedly, that one use of the general diffusion of air through the bodies of birds is to prevent their respiration from being stopped or interrupted by the rapidity of their motion through a resisting medium. The resistance of the air increases in proportion to the celerity of the motion. Were it possible for man to move with a swiftness equal to that of a swallow, the resistance of the air, as he is not provided with internal reservoirs similar

to thofe of birds, would foon fuffocate him. Neither does the difficulty he mentions, with regard to the ftructure of the oftrich, feem to contradict his theory; for though, as formerly remarked, the oftrich does not fly, he runs with aftonifhing rapidity.

The refpiration of air is not only neceffary to the exiftence of land-animals, but to that of FISHES of every denomination. Cœtaceous fifhes, or thofe of the whale-kind, refpire, like man and quadrupeds, by means of lungs; and, of courfe, they are obliged, at certain intervals, to come to the furface, in order to throw out the former air, and to take in a frefh fupply.

Inftead of lungs, the other fpecies of fifhes are furnifhed with gills, through which they refpire both water and air; for air is univerfally diffufed or mixed with every portion of water. When a free communication with the external air is prevented by ice, or by artifice, fifhes immediately difcover fymptoms of uneafinefs, and foon perifh. Ælian informs us, that, in winter, when the river Ifter was frozen, the fifhers dug holes in the ice; that great numbers of fifhes reforted to thefe holes; and that their eagernefs was fo great, that they allowed themfelves to be feized by the hands of the fifhermen. Rondeletius made many experiments on this fubject. If, fays he, fifhes are put into a narrow-mouthed veffel filled with water, and a communication with the air be preferved, the animals live, and fwim about, not for days and months only, but for feveral years. If the mouth of the veffel, however, be fo clofely fhut, either with the hand, or any other covering, that the paffage of the air is excluded, the fifhes fuddenly die. Immediately after the mouth of the veffel is clofed, the creatures rufh tumultuoufly, one above another, to the top, contending which of them fhall fooneft receive the benefit of the air *. In the fhallow parts of rivers, when frozen, many fifhes are found dead. But, when parts of a river are deep or rapid, the fifhes fly from the ice, and by this means avoid deftruction.

Thefe, and fimilar experiments, have been repeated by Mr. Willoughby, and many other modern authors; and they

* Rondeletius. lib. 4. cap. 9. S

they have uniformly been attended with the fame event. A carp, in a large veffel full of water, was placed in the receiver of an air-pump. In proportion as the air was exhaufted by working the pump, the furface of the animal's body was covered with a number of bubbles. The carp foon breathed quicker, and with more difficulty: A little after, it rofe to the furface in queft of air. The bubbles on its furface next difappeared; the belly, which before was greatly fwollen, fuddenly collapfed; and the animal funk to the bottom, and expired in convulfions.

Thus the refpiration of air is as neceffary to the exiftence of fifhes as to that of land-animals; for none of them can live long when deprived of this vivifying element. Fifhes, indeed, feem to require a fmaller quantity of air than animals who have a conftant and free communication with the atmofphere. The bodies and fluids of fifhes are colder than thofe of land-animals; and, of courfe, if Doctor Crawford's theory be well founded, fifhes require lefs air to fupport the proportionally fmall quantity of heat they poffefs.

An analogy between fifhes and birds deferves here to be noticed. Both of thefe claffes of animals are rapid in their motions; and both of them, befide refpiring by lungs, or gills, have receptacles of air within their bodies. Fifhes tranfmit fmall quantities of air through their gills; but Nature has provided moft of them with air-bags or bladders, which may anfwer the double purpofe of enabling them to afcend and defcend in the water, and to communicate a vital principle to their whole fyftem.

We fhall conclude this fubject with an account of the modes employed by Nature for tranfmitting air into the bodies of INSECTS.

In this feemingly contemptible, and often noxious clafs of animals, Nature has exhibited a wonderful diverfity of form, of manners, of inftincts, of deformity, and of beauty. But, however infignificant thefe creatures may appear to inattentive obfervers, Nature has been equally provident in the formation of their bodies, and in the means of preferving the different individuals, according to their kinds, as in the larger animals, which have the

appearance of more importance in the ſcale of being. To inſects ſhe has denied lungs ſimilar to thoſe of men, quadrupeds, birds, and fiſhes; but as the tranſmiſſion of air into their bodies was neceſſary to continue the principle of life, ſhe has furniſhed them with peculiar inſtruments and apparatus for accompliſhing this indiſpenſible purpoſe.

Air is conveyed into the bodies of inſects by inſtruments called *tracheæ*, or *ſtigmata*. The tracheæ, or windpipes, are, in many inſects, long tubes protruding externally from different parts of the body. In ſome, they proceed from the poſterior part, and have the appearance of one, two, or three tails; in others they ariſe from the back or ſides. The *ſtigmata* are ſmall holes, generally of a different colour from the reſt of the body, and run along the ſides of many caterpillars in regular and beautifully-dotted lines. That theſe tracheæ and ſtigmata are deſtined for the tranſmiſſion of air, has been proved by repeated experiments; for, when ſtopped up by the application of oil, or other unctuous ſubſtances, the animals ſoon loſe their exiſtence.

In contemplating the parts of animals, when the uſes of theſe parts are not apparent, we are apt to deceive ourſelves by raſhly ſuppoſing them to anſwer purpoſes for which they were never intended by Nature. Impreſſed with this idea, M. de Reaumur was not ſatisfied with the notion of Godart and others, that the long tails of certain worms were intended to keep them ſteady in their motions, and to prevent them from rolling. Reaumur obſerved, that theſe worms or grubs could lengthen or ſhorten their tails at pleaſure, but that they were always longer than the animal's body. Becauſe theſe tails have ſome reſemblance to that of a rat, he diſtinguiſhes the animals by the name of *rat-tailed worms*. Theſe worms are aquatic, and never appear on dry ground till they are about to undergo their firſt transformation. Reaumur, in order to obſerve their œconomy more cloſely, collected a number of rat-tailed worms, and put them into a glaſs veſſel filled two inches high with water. At firſt they were conſiderably agitated, each ſeemingly ſearching for a proper

a proper place of repoſe. Some of them ſwam acroſs, others attached themſelves to the ſides, and others reſted at the bottom of the veſſel. In a quarter of an hour they were almoſt entirely tranquil, and Reaumur ſoon diſcovered the real uſe of their long tails. Upon examining the veſſel, he found that each of the animals, in whatever ſituation they were placed, extended its tail exactly to the ſurface; that, like other aquatic inſects, the reſpiration of air was neceſſary to their exiſtence; and that the tail, which is tubular, and open at the extremity, was the organ by which this operation was performed. In this experiment, the diſtance from the bottom to the ſurface was two inches, and, of courſe, the tails were of an equal length. To diſcover how far the animals could extend their tails, this moſt ingenious and indefatigable philoſopher gradually augmented the height of the water, and the tails uniformly roſe to the ſurface till it was between five and ſix inches high. When the water was raiſed higher, the animals immediately quitted their ſtation at the bottom, and either mounted higher in the water, or fixed upon the ſides of the veſſel, in ſituations which rendered it convenient for them to reach the ſurface with the points of their tails. Theſe tails conſiſt of two tubes, both of which are capable of extenſion and contraction. The firſt tube is always viſible; but the ſecond, which is the proper organ of reſpiration, is exſerted only when the water is raiſed to a certain height. Through this tube the air is conveyed into two large tracheæ or wind-pipes within the body of the animal, and maintains the principle of life. When the tails are below the ſurface, they occaſionally emit ſmall bubbles of air, which are viſible to the naked eye; and immediately repair to the ſurface for freſh ſupplies. Theſe rat-tailed worms paſs the firſt and longeſt part of their lives under water; when near the time of their transformation, they leave the water, go under the ground, and are there transformed into chryſalids; and, laſtly, from this ſtate they are transformed into flies, and ſpend the remainder of their exiſtence in the air.

Another ſpecies of aquatic worms merit attention. They

They frequent marſhes, ditches, and ſtagnating waters. Their general colour is a greeniſh brown. Their bodies conſiſt of eleven rings; and their ſkin is not cruſtaceous, but rather reſembles parchment. Though theſe animals, before their transformation into flies, live in water, air is neceſſary to ſupport their principle of life; and the apparatus with which Nature has furniſhed them for that important purpoſe deſerves our notice. The laſt ring, or termination of their bodies, is open, and ſerves as a conductor of air. From this laſt ring proceed a number of hairs, which, when examined by the microſcope, are found to be real feathers with regular vanes. In particular ſituations, they bend the laſt ring in ſuch a manner as to reach the ſurface of the water or mud in which they are placed. Theſe feathers prevent the water from entering into the tube, or organ of reſpiration; and, when the animal raiſes the termination of its body to the ſurface, in order to receive air, it erects and ſpreads the feathers, and by this means expoſes the end of the tube to the atmoſphere. When cautiouſly cut open, two large veſſels, or tracheæ, appear on each ſide, and occupy almoſt one half of the body. Both of theſe wind-pipes terminate in the open tube, or laſt ring. Though theſe worms are furniſhed with organs of reſpiration, and actually reſpire air, yet M. de Reaumur diſcovered that ſome of them could live more than twenty-four hours without reſpiration.

So anxious is Nature to provide animals, in every ſtate of their exiſtence, with air, that, after the transformation of many inſects into chryſalids, ſhe creates inſtruments for that purpoſe, which did not exiſt previous to their transformation. The rat-tailed worms, formerly mentioned, ſoon after they are transformed into chryſalids, inſtead of a ſoft pliable ſkin, are covered with a hard cruſtaceous ſubſtance, ſeemingly impervious to the air; and the tail, which was the wind-pipe of the animal in its firſt ſtate, gradually vaniſhes. In a few hours, however, four hollow horns ſhoot out, two from the fore, and two from the hind, part of what was the head of the animal. Theſe

horns,

horns, which are hard and tubular, M. de Reaumur difcovered to be real wind-pipes, deftined for the introduction of air into the chryfalis, a ftate in which the animals have the appearance of being almoft totally dead, and, of courfe, fhould feem to have little ufe for refpiration. He likewife difcovered that thefe horns, which had pierced the hard exterior covering, terminated in as many tracheæ in the body of the animal. This fact affords a ftrong example of the neceffity of air for fuftaining the principle of life, even in its loweft condition. After thefe animals pafs from the chryfalis ftate to that of flies, they are deprived both of their tails and horns. But Nature, in this laft ftage of their exiftence, has not left them without proper refources for the introduction of air into their bodies. Inftead of protuberant tracheæ in the form of tails or horns, they now, like other flies, receive air by means of ftigmata, or holes, varioufly difpofed over different parts of the body.

The nymph of the libella, or dragon-fly, refpires water, in the fame manner as men and quadrupeds refpire air. We receive and throw out the air by the mouth and noftrils. But the nymphs of the libella receive and eject water by an aperture at the termination of their bodies. Thefe nymphs fometimes throw out the water, at certain intervals, with fuch force, that the ftream is perceptible at the diftance of two or three inches from their bodies. When kept fome time out of the water, the defire or neceffity of refpiration is augmented; and, accordingly, when replaced in a veffel filled with water, infpirations and refpirations are repeated with unufual force and frequency. If you hold one of thefe nymphs in your hand, and apply drops of water to the pofterior end of its body, it inftantly, by an apparatus fimilar to the pifton of a pump, fucks in the water, and the dimenfions of its body are vifibly augmented. This water is again quickly thrown out by the fame inftrument. But, though this infect refpires water, air feems to be not the lefs neceffary to its exiftence; for, like other infects, the whole interior part of its body is amply provided with large and convoluted

luted tracheæ; and, externally, there are ſeveral ſtigmata deſtined for the introduction of air *.

The worms, or nymphs, of the ephemeron flies merit attention. They have received the denomination of *ephemeron*, becauſe almoſt none of them ſurvive the day in which they are transformed into flies. But, many of them live not one hour after their transformation. When in the worm and nymph ſtates, they generally live in holes near the ſurface of the water; and, under theſe two forms, continue to grow till they are mature for paſſing into the laſt and ſhorteſt period of their exiſtence. Swammerdam informs us, that ſome of them remain three years under water, others two, and others one only. During their abode in this element, they are nouriſhed and prepared for their laſt and fatal change. Immediately after the males have joined their mates, and the females have depoſited their eggs in the water, both periſh, but not before they have left the rudiments of a numerous race of ſucceſſors. As long as theſe inſects live in the water, to inattentive obſervers, their general appearance is nearly the ſame. When they have paſſed, however, into nymphs, the veſtiges of wings may be perceived, which we look for in vain during their firſt or worm ſtate. In both ſtates, the inſect which is to become an ephemeron fly has ſix legs attached to the breaſt. The head is triangular, and from the baſe of each eye proceeds an articulated feeler. The body is compoſed of ten rings, from the laſt of which three tails, that probably perform the office of tracheæ, ariſe. Theſe tails, in ſome ſpecies, are as long as the animal's body, and are fringed with hairs which have a reſemblance to feathers. But, what principally deſerves our notice on this ſubject is, that, on each ſide of the body, there are ſix or ſeven protuberances, which have the appearance of ſo many oars. With theſe inſtruments the animals deſcribe arches in the water, firſt on one ſide, and then on the other, with aſtoniſhing rapidity. This circumſtance led Clutius, and ſome other authors, to think that theſe protuberances were fins, or inſtruments of motion, and that the animals were fiſhes. But Reaumur remarked that they moved theſe fins

* Reaumur, tom. 12. pag. 187. duod. edit. S.

fins with the ſame rapidity when the animals were at reſt as when they were in motion; and that, inſtead of fins, when examined by the microſcope, he diſcovered them to be gills, through which the creatures reſpire. Each gill conſiſts of a ſhort trunk, and two large branches, or tubes, which give off on all ſides a number of ſmaller ramifications, and are perfectly ſimilar to the tracheæ of other inſects. At the origin of every gill, two tracheæ penetrate the trunk, and are diſperſed through the body of the animal.

Though the ſtigmata, or reſpiratory organs, of caterpillars and other inſects, were long known to ſerve the purpoſe of inſpiration, yet it was uncertain whether the animals reſpired by the ſame orifices, till Bonnet, and, after him, Reaumur, aſcertained the fact by many curious and accurate experiments. The firſt of theſe authors immerſed numbers of caterpillars, of different kinds, and at different times, in water, and he obſerved, both with the naked eye, and by the aſſiſtance of a glaſs, bubbles of air iſſuing from various parts of their bodies, and particularly from the ſtigmata. To remove all deception from his experiments, before immerſion, he carefully moiſtened the caterpillars with water, in order to diſlodge any portions of the external air that might be adhering to their bodies. Some of them he allowed to remain ſo long under water, that they had every appearance of death. He then raiſed the head and the two anterior ſtigmata above the ſurface. The head, and firſt pair of legs, ſoon began to move from ſide to ſide; and the body neceſſarily partook of the ſame motions. During theſe movements, many bubbles of air iſſued from the poſterior and intermediate ſtigmata, which ſtill remained under water; but the membranous limbs continued nearly at reſt. He next kept a caterpillar under water till all motion was ſuſpended. Then he elevated the anus and the two laſt ſtigmata above the ſurface, that they might have a communication with the external air. He kept the animal in this ſituation about half an hour, without any ſymptoms of re-animation. After raiſing the body ſucceſſively from the laſt to the firſt pair of ſtigmata, ſtill the animal exhibited

bited no ſymptoms of life; but, when he expoſed the whole body to the external air for half an hour, the powers of life completely returned. After ſuſpending the caterpillar about two hours with the laſt five pair of ſtigmata above the ſurface, he found that life was not extinguiſhed. He then raiſed the water till the anus and laſt pair of ſtigmata only were expoſed to the atmoſphere. He allowed the caterpillar to remain in this ſituation more than half an hour; and he obſerved that it often bended its body with a view to reach the ſurface, and that, during theſe efforts, bubbles of air iſſued from the anterior, but not from the poſterior, ſtigmata. He likewiſe remarked, that, on the ſmalleſt motion of the animal, theſe bubbles were diſcharged, but that they were augmented both in quantity and ſize, in proportion to the agitations of the body. M. Bonnet immediately raiſed the water till it covered the two laſt ſtigmata; the caterpillar was violently agitated; but no bubbles of air, the communication being cut off, appeared, and all motion ceaſed. He inſtantly lowered the water, and expoſed the two poſterior ſtigmata to the air; the animal reſumed it movements; but in a moment after it expired. By another experiment, M. Bonnet diſcovered that a caterpillar lived eight days ſuſpended in water, during all which time it breathed ſolely by the two poſterior ſtigmata.

After theſe, and mány other facts of a ſimilar kind, which demonſtrate that air is neceſſary for the ſupport and continuation of animal life, it ſhall only be remarked, that, when caterpillars undergo their laſt change, and appear in the form of flies of every denomination, Nature has ſtill furniſhed them with ſtigmata, or reſpiratory organs.

Reptiles of all kinds are likewiſe furniſhed with organs of reſpiration. Land-ſnails, at the approach of winter, bury themſelves in the earth, or retire into holes of rocks, or of old buildings, where they remain in a torpid ſtate during the ſeverity of the ſeaſon. For protection and warmth, theſe animals, when they go into their winter habitations, form, by means of a ſlime or ſaliva that iſ-

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ſues from every pore of their bodies, a membranous cover, which ſtops up the mouths of their ſhells. But this pellicle, or cover, though apparently pretty hard and ſolid, is ſo thin and porous as not entirely to exclude the entrance of air, without which the principle of life could not be continued. Accordingly, when, by accident, the pellicle is made too thick, and prevents a communication with the external air, the animal, to remedy the evil, makes a ſmall aperture in its cover. In this ſtate ſnails remain ſix or ſeven months, without food or motion, till the genial warmth of the ſpring breaks their ſlumber, and calls forth their active powers. Hence it ſhould appear, that air is more neceſſary to the preſervation of animal life than food itſelf; for, in numberleſs inſtances, animals can live, not for days or weeks, but for months, without ſupplies of nouriſhment. None of them, however, are capable of exiſting nearly ſo long without having ſome communication with the air.

With regard to ſnails that live in freſh waters, or in the ocean, the ſpecies of which are numerous, their manner of reſpiring is ſingular. All of them have an aperture on the right ſide of the neck. This aperture ſerves the complicated purpoſes of diſcharging the fæces, of lodging the organs of generation, of aſcending and deſcending in the water, and of reſpiration. They are frequently obſerved to ſtraiten the orifice of this aperture, to ſtretch it out in the form of an oblong tube; and, in this ſtate, they riſe to the ſurface, in order to expel the former air, and take in a new ſupply.

But, though air ſeems to be an indiſpenſible principle of animal life, yet many animals can live longer without the uſe of this element, or at leaſt with ſmaller quantities of it, than others. Even men, by long practice, acquire the faculty of retaining the air in their lungs for an almoſt incredible length of time. Some of thoſe wretched creatures who are compelled by tyranny to dive for pearl-oyſters, have been known to continue under water three quarters of an hour without receiving a freſh ſupply of air. Thoſe animals which lie torpid during the winter, as the hedge-hog, the dormouſe, the marmot,

&c. though perhaps not entirely deprived of all communication with the air, exiſt, without any apparent breathing, till the heat of the ſpring reſtores their wonted powers of life, when the reſpiration of air becomes again equally neceſſary as before their torpor commenced. The toad, like all the frog-kind, is torpid in winter. At the approach of winter, the toad retires to the hollow root of a tree, to the cleft of a rock, and ſometimes to the bottom of a ditch, or pond, where it remains for months in a ſtate of ſeeming inſenſibility. In this laſt ſituation, it can have very little communication with the air. But ſtill the principle of life is continued, and the animal revives in the ſpring. What is more wonderful, toads have been found, in a hundred places of the globe, incloſed in the heart of ſolid rocks, and in the bodies of trees, where they have been ſuppoſed to exiſt for centuries, without any apparent acceſs either to nouriſhment or to air; and yet they were alive and vigorous. In the Memoirs of the Academy of Sciences for the year 1719, we have an account of a toad found alive, and healthy, in the heart of an old elm. Another, in the year 1731, was diſcovered, near Nantz, in the heart of an old oak, without any viſible entrance to its habitation. From the ſize of the tree, it was concluded, that the animal muſt have been confined in that ſituation at leaſt eighty or a hundred years. In the many examples of toads found in ſolid rocks, exact impreſſions of the animals bodies, correſponding to their reſpective ſizes, were uniformly left in the ſtones or trees from which they were diſlodged; and, to this day, it is ſaid, that there is a marble chimney-piece at Chatſworth with a print of a toad in it; and a traditionary account of the place and manner in which it was diſcovered.

Theſe, and ſimilar facts, are ſupported by authorities ſo numerous and ſo reſpectable, that it is unneceſſary to quote them. Many abortive attempts have been made to account for an animal's growing and living very long in the ſituations above deſcribed, without the poſſibility of receiving nouriſhment or air; eſpecially as, like all other animals, when put into an exhauſted receiver, the

toad

toad ſoon loſes its exiſtence. Upon this ſubject I ſhall only hazard two obſervations. The toad, it is well known, when kept in a damp place, can live ſeveral months without food of any kind, though, in its ſtate of natural liberty, it devours voraciouſly ſpiders, maggots, ants, and other inſects. Here we have an inſtance, and there are many, of an animal whoſe conſtitution is ſo framed by Nature, that it can exiſt ſeveral months without receiving any portion of food. According to our ideas of the neceſſity of frequent ſupplies of nouriſhment, it is nearly as difficult for us to conceive an abſtinence of four or ſix months as one of as many years, or even centuries. The one fact, therefore, though we are unable to account for either, may be as readily admitted as the other. The ſame remark is equally applicable to the regular reſpiration of air. The toad, and many other animals, from ſome peculiarity in their conſtitution, can live very long in a torpid ſtate without ſeeming to reſpire, and yet their principle of life is not entirely extinguiſhed. Hence the toad may, and actually does, live many years in ſituations which exclude a free intercourſe with the external air. Beſides, almoſt all the above, and ſimilar facts, muſt, from their nature, have been diſcovered by common labourers, who are totally unqualified for examining every circumſtance with the diſcerning eye of a philoſopher. In rocks there are many chinks, as well as fiſſures, both horizontal and perpendicular; and in old trees nothing is more frequent than holes and vacuities of different dimenſions. Through theſe fiſſures and vacuities the eggs of toads may accidentally be conveyed by water, the penetration of which few ſubſtances are capable of reſiſting. After the eggs are hatched, the animals may receive moiſture, and ſmall portions of air, through the crevices of rocks, or the channels of aged trees. But, I mean not to perſuade; for I cannot ſatisfy myſelf. All I intend is, to recommend to thoſe gentlemen who may hereafter chance to ſee ſuch rare phænomena, a ſtrict examination of every circumſtance that can throw light upon a ſubject ſo dark and myſterious; for the vulgar, ever inclined to

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render uncommon appearances ſtill more marvellous, are not to be truſted.

From the facts I have enumerated, it is apparent that air, in certain proportions, according to the ſtructure and conſtitution of every animated being of which we have any knowledge, is indiſpenſibly neceſſary for the exiſtence and continuation of animal life. Not only men, quadrupeds, birds, fiſhes, reptiles, and the larger inſects, but even fleas, mites, the minute eels found in paſte or in vinegar, and the animalcules produced by infuſing animal or vegetable ſubſtances in water, inevitably periſh when deprived of this all-vivifying element.

With regard to plants, air is ſo neceſſary to their exiſtence, that they do not vegetate in an exhauſted receiver. Plants, as formerly mentioned, are furniſhed with numerous air-veſſels, or reſpiratory organs. They abſorb and tranſmit air through every pore. When placed in an exhauſted receiver, the air contained in every part of their ſubſtance is ſoon extracted; and, in proportion as this air is likewiſe pumped out by the machine, the flowers and leaves ſhow evident ſymtoms of debility; they become flaccid, pendulous, and aſſume a ſickly appearance; and, if retained in that ſituation a certain length of time, their vegetating powers are irrecoverably extinguiſhed.

Upon the whole, as the air we continually breathe is an univerſal menſtruum, and, of courſe, liable to be impregnated with exhalations from every ſubſtance to which it has acceſs, the great importance of perſonal, as well as of domeſtic, cleanlineſs, is an obvious reflection. In building towns or houſes, the ſituation, with regard to air, is a capital object. The vicinity of marſhes, of ſtagnating waters, of manufactures of tallow, oil, ſal-ammoniac, the ſmelting or corroding of metals of every kind, and many other operations which contaminate the air, ſhould be either avoided or removed, as they are the peſts of our ſenſes, and the poiſoners of our conſtitutions. Even in northern climates, houſes ſurrounded with trees, or in the neighbourhood of luxuriant vegetables, are always damp, and infeſted with inſects; and hence the ambient air is replete with the ſeeds of diſeaſe. Precautions

cautions of this kind are ſtill more neceſſary in hot climates. Air, like other menſtruums, abſorbs a greater or leſs proportion of the particles of bodies, according to its degree of heat. In Madrid, however, in Conſtantinople, and in many other cities of warm regions, the houſes are crowded together, the ſtreets are narrow, and covered with filth of every kind. We cannot, therefore, be ſurpriſed, that human beings exiſting in ſuch ſituations ſhould be ſo frequently infected with peſtilential diſeaſes.

CHAPTER IV.

Of Motion.

MOTION, in the opinion of Ariſtotle, and the admirers of antient philoſophy, can only be produced by mind; and hence they define *mind* to be the *power of moving*. By the ſame mode of reaſoning, it may be ſaid that *reſt*, or *inactivity*, is the *power of being moved*. But ſuch ſpeculations are foreign to the nature of this work, and perhaps fruitleſs in themſelves. Though it is impoſſible to give an unexceptionable definition of motion, the phænomenon itſelf is obvious to every man's ſenſes.

All the terreſtrial objects which preſent themſelves to our obſervation are, with regard to motion, diſtinguiſhable into two general claſſes. The firſt conſiſts of thoſe which are endowed with a ſpontaneous, or ſelf-moving, power, and with ſome qualities and affections ſimilar to thoſe of our minds. The ſecond conſiſts of all thoſe objects in which no ſuch qualities and affections appear, and are of a nature ſo paſſive, that they never move of themſelves, nor, when put in motion, do they ever ſtop without ſome external influence or reſiſtance. The firſt claſs of objects, from their poſſeſſing the power of ſpontaneous motion, and other qualities peculiar to animated beings, are eaſily diſtinguiſhed from body, or matter, which is totally deprived

prived of all these qualities. In consequence of its passive nature, matter not only never changes its state without external force, but resists when any such change is attempted to be made. When at rest, it cannot be put in motion without difficulty; and, when in motion, a certain force is required to stop its course. The force with which matter perseveres in its state, and resists any change, is called its *vis inertiæ*, and is always proportional to the quantity of matter in any particular body. When we double or triple a body, we uniformly find, that the force requisite to move it with equal celerity must likewise be doubled or tripled. These, and similar facts, which are results of perpetual experience, show that body is equally indifferent to motion and rest; that this indifference seems to be the natural consequence of the most absolute inactivity; and that the power of beginning motion is peculiar to active and intelligent beings. Leaving, therefore, all metaphysical speculations on this subject, we shall give some remarks upon the motions of animals.

In general, all the progressive motions of animals are performed by the instrumentality of muscles, tendons, and articulations. The operation of muscles depends upon some unknown influence derived to them from the brain and nerves. Hence the brain and nerves are the sources of every motion, as well as of every sensation. With regard to the causes which determine the actions of animals, these must be referred to sensation, and the consequent exertions of intellect. The first impression an object makes upon our sensations stimulates us either to approach or retire from it, according as it excites affection or aversion. These motions necessarily result from the first impression made by the object. But man, and many other animals, have the power of resisting these original motives to action, and of remaining at rest, without either retiring or approaching. 'If a man,' says the Count de Buffon, 'were deprived of sight, he would make no movement to gratify his eyes. The same thing would happen, if he were deprived of any of the other senses; and, if deprived of every sense, he would remain perpetually at rest, and no object would excite him to move, though,

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'by natural conformation, he were fully capable of mo-'tion.' Natural wants, as that of taking nouriſhment, neceſſarily excite deſire or appetite. But, if a man be deprived of ſenſation, want cannot exiſt, becauſe all its ſources are annihilated. This is cutting off all the cauſes, and at the ſame time looking for the effects. An animal without ſome ſenſation is no animal, but a dead maſs of matter. Sentiment is the only ſtimulus to animal motion; the aptneſs of the parts produces the effect, which varies according to the ſtructure and deſtination of theſe parts. The ſenſe of want creates deſire. Whenever an animal perceives an object fitted to ſupply its wants, deſire is the neceſſary conſequence, and action or motion inſtantly ſucceeds.

Beſide progreſſive motion, the motion of hands, and other parts of animal bodies, which are all effected by means of muſcles, and are ſubject to the will of the creatures who perform them, there are other motions that have little or no dependence on our inclinations. Of this kind are the action of the heart, the circulation of the blood, the digeſtion of food, the periſtaltic motion of the bowels, the progreſs of the chyle from the ſtomach and inteſtines to the ſubclavian vein, the movement of the various ſecreted liquors, ſuch as the gall, the urine, the ſaliva, &c. Theſe, together with the action of the lungs in reſpiration, have received the denomination of *vital* and *involuntary motions*, becauſe moſt of them go on without any conſcious exertions of the intellectual principle. If ſuch a variety of nice and complicated movements had been left to the determination and direction of our minds, they muſt neceſſarily have occupied too much of our attention; and many of them would infallibly have been neglected during ſleep, when conſciouſneſs is often almoſt totally ſuſpended. But Nature in her operations is always wiſe. She has given to man, and other animals, the direction of no movements but what are eaſily performed, contribute to pleaſure and health, and enable them to acquire food correſponding to the ſtructure of their bodies and the elements in which they live.

It never was my intention, and, indeed, it would have been

been foreign to the deſign of this work, and ill ſuited to that claſs of mankind to whom I wiſh chiefly to be uſeful, to enter into the *rationale* of animal motion; to mention the number, inſertion, and direction, of the muſcles employed in moving the different parts of animated bodies; or to account for the modes by which animals walk, leap, fly, ſwim, creep, &c. Such diſcuſſions would not only require a volume, but a thorough acquaintance with all the depths of anatomical and mathematical knowledge. What follows, therefore, will conſiſt of ſome deſultory obſervations; and the ſubject ſhall be concluded by enumerating a few examples of movements peculiar to certain animals.

The motions of animals are proportioned to their weight and ſtructure. A flea can leap ſome hundred times its own length. Were an elephant, a camel, or a horſe, to leap in the ſame proportion, their weight would cruſh them to atoms. The ſame remark is applicable to ſpiders, worms, and other inſects. The ſoftneſs of their texture, and the comparative ſmallneſs of their ſpecific gravity, enable them to fall with impunity from heights that would prove fatal to larger and heavier animals.

Motion gives birth, perfection, death, and reproduction, to all animal and vegetable beings. It is the cauſe of all that diverſity and change which perpetually affect every object in the univerſe. The globe we inhabit, as well as the innumerable and ſtupendous heavenly bodies which preſent themſelves, in forms apparently minute, to our obſervation, conſtantly exhibit motions of the moſt inconceivable rapidity. The magnitude of this earth, when conſidered with relation to man, and other animals, appears to be exceedingly great. It is indeed ſufficiently ſpacious, and ſufficiently prolific, for the conveniency and maintenance of its inhabitants. The magnificent objects diſplayed on its ſurface excite the admiration of every beholder. Its plains and mountains, its rivers and lakes, its iſlands and continents, its ſeas and oceans, continually ſolicit attention, gratify curioſity, and call forth the powers of reaſon, and reflection. But, when compared to the other heavenly bodies, the number and magnitude of

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which exceed all the powers of human conception, the grandeur of our earth diminiſhes. Inſtead of exciting wonder, it almoſt vaniſhes from our ſight. Inſtead of an immenſe globe, it dwindles into a point, ſeems to occupy no ſpace, and loſes itſelf in the boundleſs regions of the univerſe. Conſiderations of this kind are apt to depreſs the dignity of man, and to leſſen his importance in the great ſcale of being; but they expand his mental faculties, and exalt his ideas concerning that inconceivable Power which firſt produced, and ſtill ſupports, thoſe aſtoniſhing orbs.

The different movements to which animals are ſtimulated by the deſire of food, by love, by the appetite for frolic and exerciſe, by their hoſtilities, and by other exciting cauſes, give animation and vivacity to the whole ſcene of nature. A ſilent and motionleſs proſpect, however beautiful and variegated, ſoon ceaſes to pleaſe, and at laſt becomes inſupportable. Motion, ſays Mr. Harris, is the object or cauſe of all ſenſation. In muſic we hear it; in ſavours we taſte it; in odours we ſmell it; in touch we feel it; in light we ſee it.

Animals furniſhed with deſtructive weapons, or endowed with uncommon ſtrength, courage, or ingenuity, are proportionally ſlower in their movements than the weaker kinds. The ſame remark is applicable to thoſe ſpecies whoſe food is always at hand. Worms, caterpillars, and many other inſects, in order to procure nouriſhment, are under no neceſſity of taking an extenſive range. But, the motions of birds and fiſhes are extremely rapid; becauſe, in queſt of food, they are obliged to paſs through large tracts, and they have alſo many enemies to avoid.

Timid animals, as the hare, the rabbit, the Guiney-pig, &c. are almoſt perpetually in motion. Even when perfectly undiſturbed, they are reſtleſs, and betray a continual anxiety of danger. They run about, ſtop ſhort, erect their ears, and liſten. The Guiney-pig frequently raiſes itſelf on its hind-legs, and ſnuffs all around to catch the ſcent of food when hungry, or to increaſe its circle of hearing when afraid.

The movements of many animals are ſo extremely ſlow, that ſome of them, particularly thoſe of the ſhell tribes, are generally ſuppoſed to be deſtitute of the power of moving. It is a common notion, that both freſh and ſalt water muſcles have not the loco-motive faculty. But, this is a vulgar error. It is almoſt unneceſſary to mention, that the exterior part of muſcles conſiſts of two ſhells hinged together, which the animals can open or ſhut at pleaſure. Every perſon muſt likewiſe have obſerved, in the ſtructure of the animal itſelf, a fleſhy protuberance of a much redder colour, and denſer conſiſtence, than the other parts of the body. This muſcular protuberance, which conſiſts of two lobes, has been denominated a *trunk*, or *tongue:* But it is an inſtrument by which the creature is enabled to perform a progreſſive, though a very ſlow, motion; and, therefore, in deſcribing its manner of moving, I ſhall call theſe two lobes the animal's *tentacula*, or *feet*.

When inclined to remove from its preſent ſituation, the river-muſcle opens its ſhell, thruſts out its tentacula, and, while lying on its ſide in an horizontal poſition, digs a ſmall furrow in the ſand. Into this furrow, by the operation of the ſame tentacula, the animal makes the ſhell fall, and thus brings it into a vertical poſition. We have now got our muſcle on end; but how is he to proceed? He ſtretches forward his tentacula, by which he throws back the ſand, lengthens the furrow, and this fulcrum enables him to proceed on his journey.

With regard to marine muſcles, their progreſſive motion is performed in the ſame manner, and by the ſame inſtruments. When not in motion, they are all firmly attached to rocks, or ſmall ſtones, by many threads of about two inches in length, which ſerve the double purpoſes of an anchor and cable. Without this proviſion of Nature, theſe animals muſt become the ſport of the waves, and the ſpecies would ſoon be annihilated. But, how does the creature ſpin theſe threads? A cylindrical canal extends from the origin to the extremity of the tentacula. In this canal an extremely glutenous ſubſtance is ſecreted, which the animal, by the operation of certain muſcles,

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has the power of forcing out, and of attaching it, in the form of ſtrong threads, to ſtones or other ſolid bodies. More than a hundred and fifty of theſe cables are often employed in mooring a ſingle muſcle*. The ſubſtance of the threads is exceedingly viſcous, indigeſtible in the human ſtomach, and is probably the cauſe of thoſe fatal conſequences which ſometimes happens to inattentive eaters. In Scotland, theſe threads are called the *beards* of muſcles, and ſhould be carefully pulled off before the animals are thrown into the ſtomach.

Other bivalved ſhell-fiſhes, the ſpecies of which are numerous, perform a progreſſive or retrograde motion by an inſtrument that has no ſmall reſemblance to a leg and foot. But the animals can, at pleaſure, make this leg aſſume almoſt every kind of form, according as their exigencies may require. By this leg they are not only enabled to creep, to ſink into the mud, or diſengage themſelves from it, but to perform a motion, which no man could ſuppoſe ſhell-fiſhes were capable of performing. When the tellina, or limpin, is about to make a ſpring, it puts the ſhell on the point, or ſummit, as if with a view to diminiſh friction. It then ſtretches out the leg as far as poſſible, makes it embrace a portion of the ſhell, and, by a ſudden movement, ſimilar to that of a ſpring let looſe, it ſtrikes the earth with its leg, and actually leaps to a conſiderable diſtance†.

The ſpout-fiſh ‡ has a bivalved ſhell, which reſembles the handle of a razor. This animal is incapable of progreſſive motion on the ſurface; but it digs a hole or cell in the ſand, ſometimes two feet in depth, in which it can aſcend and deſcend at pleaſure. The inſtrument or leg by which it performs all its movements is ſituated at the centre. This leg is fleſhy, cylindrical, and pretty long. When neceſſary, the animal can make the termination of the leg aſſume the form of a ball. The ſpout-fiſh, when lying on the ſurface of the ſand, and about to ſink into it, extends its leg from the inferior end of the ſhell, and makes

* Oeuvres de Bonnet, tom. 5. pag. 361. 4to edit. S.

† Ibid page 361. S.

‡ The name of the animal in Scotland. In England it is called *razor-fiſh*. S. It is the genus *Solen* of Linnæus.

makes the extremity of it take on the form of a ſhovel, ſharp on each ſide, and terminating in a point. With this inſtrument the animal cuts a hole in the ſand. After the hole is made, it advances the leg ſtill farther into the ſand, makes it aſſume the form of a hook, and with this hook, as a fulcrum, it obliges the ſhell to deſcend into the hole. In this manner the animal operates till the ſhell totally diſappears. When it chuſes to regain the ſurface, it puts the termination of the leg into the ſhape of a ball, and makes an effort to extend the whole leg; but the ball prevents any farther deſcent, and the muſcular effort neceſſarily puſhes the ſhell upward till it reaches the ſurface or top of the hole. It is amazing with what dexterity and quickneſs theſe ſeemingly-aukward motions are performed.

It is remarkable that the ſpout-fiſh, though it lives in ſalt water, abhors ſalt. When a little ſalt is thrown into the hole, the animal inſtantly quits his habitation. But, it is ſtill more remarkable, that, if you ſeize the animal with your hand, and afterwards allow it to retire into its cell, you may ſtrew as much ſalt upon it as you pleaſe, but the fiſh will never again make its appearance. If you do not handle the animal, by applying ſalt, you may make it come to the ſurface as often as you incline; and fiſhermen often make uſe of this ſtratagem. This behaviour indicates more ſentiment and recollection than one ſhould naturally expect for a ſpout-fiſh.

The ſcallop, another well known bivalved ſhell-fiſh, has the power of progreſſive motion upon land, and likewiſe of ſwimming on the ſurface of the water. When this animal happens to be deſerted by the tide, it opens its ſhell to the full extent, then ſhuts it with a ſudden jerk, by which it often riſes five or ſix inches from the ground. In this manner it tumbles forward till it regains the water. When the ſea is calm, troops, or little fleets, of ſcallops, are often obſerved ſwimming on the ſurface. They raiſe one valve of their ſhell above the ſurface, which becomes a kind of ſail, while the other remains under the water, and anſwers the purpoſe of an anchor, by ſteadying the animal, and preventing its being overſet. When an enemy approaches, they inſtantly ſhut their ſhells, plunge to the

the bottom, and the whole fleet disappears. By what means they are enabled to regain the surface, we are still ignorant.

With regard to the loco-motive faculty of the oyster, the following facts are recorded in the *Journal de Physique* by the Abbé Dicquemare. Like many other bivalved shell-fish, the oyster has the power of squirting out water with a considerable force. By thus suddenly and forcibly ejecting a quantity of water, the animal repulses such enemies as endeavour to insinuate into its shell while open. By the same operation, if not firmly attached to rocks, to stones, or to one another, the oyster retreats backwards, or starts to a side in a lateral direction. Any person may amuse himself with the squirting and motions of oysters, by putting them in a plate situated in a horizontal position, and which contains as much sea-water as is sufficient to cover them. The oyster has been represented by many authors as an animal destitute not only of motion, but of every species of sensation. The Abbé Dicquemare, however, has shown, that it can perform movements perfectly consonant to its wants, to the dangers it apprehends, and to the enemies by which it is attacked. Instead of being destitute of all sensation, oysters are capable of deriving knowledge from experience. When removed from situations which are constantly covered with the sea, devoid of experience, they open their shells, lose their water, and die in a few days. But, even when taken from similar situations, and laid down in places from which the sea occasionally retires, they feel the effects of the sun's rays, or of the cold air, or perhaps apprehend the attacks of enemies, and accordingly learn to keep their shells close till the tide returns. Conduct of this kind plainly indicates both sensation and a degree of intelligence.

The progressive motion of the sea-urchin, or sea-egg *, a well known multivalved shell-fish, merits our attention. This animal, of which there are several species, is round, oval, or shaped like a bias-bowl. The surface of the shell is divided into beautiful triangular compartments, and covered

* The *Echinus* of Linnæus.

vered with numberlefs prickles; from which laft circumftance it has received the appellation of *fea-urchin*, or *fea-hedge-hog*. Thefe triangles are feparated by regular belts, and perforated by a great number of holes. Each hole gives lodgement to a flefhy horn fimilar to thofe of the fnail, and fufceptible of the fame movements. Like the fnail, the fea-urchin ufes its horns when in motion; but their principal ufe is to fix the animal to rocks, ftones, or the bottom of the ocean. By means of the horns and prickles, which proceed from almoft every point of the fhell, the fea-urchin is enabled to walk either on its back or on its belly. The limbs it moft generally employs are thofe which furround the mouth. But, when it choofes, it can move forward, by turning on itfelf like the wheel of a coach. Thus, the fea-urchin furnifhes an example of an animal employing many thoufand limbs in its various movements. The reader may try to conceive the number of mufcles, of fibres, and of other apparatus, which are requifite to the progreffive motion of this little animal.

The motion of that fpecies of medufa, or fea-nettle, which attaches itfelf to rocks, and to the larger fhell-fifh, is extremely flow. The fea-nettles affume fuch a variety of figures, that it is impoffible to defcribe them under any determinate fhape. In general, their bodies have a refemblance to a truncated cone. The bafe of the cone is applied to the rock, or other fubftance to which they adhere. With regard to colour, fome of them are red, fome greenifh, fome whitifh, and others are brown. When the mouth, which is very large, is expanded, its margin is furrounded with a great number of flefhy filaments, or horns, fimilar to thofe of the fnail. Thefe horns are difpofed in three rows around the mouth, and give the animal the appearance of a flower. Through each of thefe horns the fea-nettle fquirts water, like fo many jets-d'eau. What is peculiar in the ftructure of thefe creatures, the whole interior part of their body, or cone, is one cavity, or ftomach. When fearching for food, they extend their filaments, and entangle any fmall animals they encounter. When they meet with their prey,
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they inſtantly ſwallow it, and ſhut their mouths cloſe like a purſe. Though the animal ſhould not exceed an inch, or an inch and an half, in diameter, as it is all mouth and ſtomach, it ſwallows large whelks and muſcles. Theſe ſhell-animals ſometimes remain many days in the ſtomach before they are ejected. Their nutrifying parts are at laſt, however, extracted; but how does the ſea-nettle get quit of the ſhell? The creature has no other aperture in its body but the mouth, and this mouth is the inſtrument by which it both receives nouriſhment, and diſcharges the excrement, or unprofitable part of its food. When the ſhell is not too large, the ſea-nettle has the power of turning its inſide out, and by this ſtrange manœuvre the ſhell is thrown out of the body, and the animal reſumes its former ſtate. But, when the ſhell preſents itſelf in a wrong poſition, the animal cannot diſcharge it in the uſual manner; but, what is extremely ſingular, near the baſe of the cone, the body of the creature ſplits, as if a large wound had been made with a knife, and through this gaſh the ſhell of the muſcle, or other ſhell, is ejected.

With regard to the progreſſive motion of the ſea-nettle, it is as ſlow as the hour-hand of a clock. The whole external part of its body is furniſhed with numerous muſcles. Theſe muſcles are tubular, and filled with a fluid, which makes them project in the form of prickles. By the inſtrumentality of theſe muſcles, the animal is enabled to perform the very ſlow motion juſt now mentioned. But this is not the only means by which the ſea-nettle is capable of moving. When it pleaſes, it can looſen the baſe of the cone by which it is attached to the rock, reverſe its body, and employ the filaments round its mouth as ſo many limbs. Still, however, its movements are imperceptibly ſlow. For theſe facts, ſeveral authors might be quoted; but we ſhall refer the reader ſolely to M. de Bonnet *.

Before we conclude this chapter, we ſhall juſt mention a mode of flying which is peculiar to certain inſects. The *maſon-bee*, which is one of the ſolitary ſpecies, has received that appellation, becauſe it conſtructs a neſt with mud,

* Oeuvres de Bonnet, 4to edit. tom. 5. pag. 345. S.

mud, or mortar. Externally, this neſt has no regular appearance; and is, therefore, generally regarded as a piece of dirt accidentally adhering to a wall. This habitation, however unſeemly in its exterior aſpect, is furniſhed with regular cells, and often gives riſe to great conflicts. When the real proprietor is abroad in queſt of materials to finiſh the neſt, a ſtranger takes poſſeſſion. At meeting, a battle always enſues. This battle is fought in the air. Sometimes they fly with ſuch rapidity and force againſt each other, that both parties fall to the ground. But, in general, like birds of prey, the one endeavours to riſe above the other, and to give a downward blow. To avoid the ſtroke, the undermoſt, inſtead of flying forward, or laterally, is frequently obſerved to fly backward. This retrograde flight is likewiſe performed occaſionally by the common houſe-fly, and ſome other inſects, though we are unable to perceive what ſtimulates them to perform this uncommon movement.

CHAPTER V.

Of the Inſtinct of Animals—Diviſion of Inſtincts—Examples of Pure Inſtinct—Of ſuch Inſtincts as can accommodate themſelves to peculiar circumſtances and ſituations—Of Inſtincts improveable by obſervation and experience—Some remarks and concluſions from this view of Inſtinct.

MANY theories have been invented with a view to explain the inſtinctive actions of animals; but none of them have received the general approbation of Philoſophers. This want of ſucceſs in the inveſtigation of a ſubject ſo curious and ſo intereſting, muſt be owing to the operation of ſome powerful cauſes. Two of theſe cauſes appear to be, a want of attention to the general œconomy and manners of animals, and miſtaken notions concerning

ing the dignity of human nature. From perufing the compofitions of moft authors who have written upon animal inftinct, it is evident, that they have chiefly derived their ideas, not from the various mental qualities difcoverable in different fpecies of animals, but from the feelings and propenfities of their own minds. Some of them, at the fame time, are fo averfe to allow brutes a participation of that intellect which man poffeffes in fuch an eminent degree, that they confider every animal action to be the refult of pure mechanifm. But the great fource of error on this fubject is, the uniform attempt to diftinguifh inftinctive from rational motives. I fhall, however, endeavour to fhow that no fuch diftinction exifts, and that the reafoning faculty itfelf is a neceffary refult of inftinct.

The proper method of inveftigating fubjects of this kind, is to collect and arrange the facts which have been difcovered, and to confider whether thefe facts lead to any general conclufions. This method I have adopted; and fhall therefore exhibit examples of pure inftincts; of fuch inftincts as can accommodate themfelves to peculiar circumftances and fituations; and of inftincts improveable by obfervation and experience. In the laft place, I fhall draw fome conclufions.

I. *Of Pure Inftincts.*

By *pure* inftincts, I mean thofe, which, independent of all inftruction and experience, inftantaneoufly produce certain actions when particular objects are prefented to animals, or when they are influenced by peculiar feelings. Of this clafs the following are examples.

In the human fpecies, the inftinct of fucking is exerted immediately after birth. This inftinct is not excited by any fmell peculiar to the mother, to milk, or to any other fubftance; for infants fuck indifcriminately every thing brought into contact with their mouths. The defire of fucking, therefore, is innate, and coeval with the appetite for air.

The voiding of urine and excrement, fneezing, retraction of the mufcles upon the application of any pain-

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ful ſtimulus, the moving of the eye-lids, and other parts of the body, are likewiſe effects of original inſtincts, and eſſential to the exiſtence of young animals.

The love of light is exhibited by infants at a very early period. I have remarked evident ſymptoms of this attachment on the third day after birth. When children are farther advanced, marks of the various paſſions gradually appear. The paſſion of fear is diſcoverable at the age of two months. It is called forth by approaching the hand to the child's eye, and by any ſudden motion or unuſual noiſe. I once inſtituted a courſe of experiments to aſcertain the periods when the various paſſions, principles, or propenſities, of the human mind are unfolded, and to mark the cauſes which firſt produced them. But, in leſs than five months after the birth of the child, the buſineſs became too complicated and extenſive for the time I had to beſtow on ſubjects of this nature.

The brute creation affords innumerable examples of pure inſtincts.

When caterpillars are ſhaken off a tree in every direction, all of them inſtantly turn toward the trunk, and climb up, though they had never formerly been on the ſurface of the ground.

Young birds open their mouths upon hearing any kind of noiſe, as well as that of their mother's voice. They have no apprehenſions of harm; neither do they offer to uſe their wings till they acquire more ſtrength and experience. The lion's cub is not ferocious till he feels force and activity for deſtruction.

Inſects invariably depoſit their eggs in ſituations moſt favourable for hatching and affording nouriſhment to their future progeny. Butterflies, and other inſects, whoſe offspring feed upon vegetables, uniformly fix their eggs upon ſuch plants as are moſt agreeable to the palate and conſtitution of their young. Water inſects never depoſit their eggs on dry ground. I have ſeen butterflies which had been transformed in the houſe, exhibit marks of the greateſt uneaſineſs becauſe they could not find a proper nidus for their eggs; and, when every other reſource failed, they paſted the eggs on the panes of the window.

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Some ſpecies of animals look not to future wants. Others, as the bee and the beaver, are endowed with an inſtinct which has the appearance of foreſight. They conſtruct magazines, and fill them with proviſions.

The common bees attend the female, or queen, do her many little ſervices, and even feed her with honey from their trunks*. When deprived of the female, all their labours ceaſe †, till a new one is obtained, whom they treat with much reſpect, and renew their uſual operations §. They make cells of three different dimenſions, for holding workers, drones, and females; and the queen-bee, in depoſiting her eggs, diſtinguiſhes the three different kinds, and never puts a royal or a drone egg into the cells deſtined for the reception of the working bees. What is equally ſingular, the number of theſe cells is proportioned to that of the different bees to be produced. One royal cell weighs as much as one hundred of the common kind ‖. When there are ſeveral females in a hive, the bees work little till they have deſtroyed all the females but one. If more than a ſingle female were allowed to remain in a hive, a greater number of eggs would be laid than the working bees are able to make cells for receiving them.

The wood-piercing bee, which is one of the ſolitary ſpecies, gnaws, with amazing dexterity and perſeverance, a large hole in old timber. After laying her eggs in the cells, ſhe depoſits ſuch a quantity of glutinous matter as nouriſhes the worms produced from theſe eggs till the time of their transformation into flies. She then paſtes up the mouth of the hole, and leaves her future offspring to the proviſion ſhe has made for them.

The bees of that ſpecies which build cylindrical neſts with roſe-leaves, exhibit a very peculiar inſtinct. They firſt dig a cylindrical hole in the earth. When that operation is finiſhed, they go in queſt of roſe-buſhes; and, after ſelecting leaves proper for their purpoſe, they cut oblong, curved, and even round pieces, exactly ſuited to form the different parts of the cylinder ¶.

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* Reaumur, 12mo edit. vol. 9. pag. 300. S. † Ibid. pag. 320. S.
§ Ibid. pag. 340. S. ‖ Ibid. tom. 10. pag. 124.
¶ Ibid. tom. 11. pag. 138. S.

The ſolitary waſp digs holes in the ſand. In each hole ſhe depoſits an egg. But how is the worm, after it is hatched, to be nouriſhed? Here the inſtinct of the mother merits attention. Though ſhe feeds not upon fleſh herſelf, and certainly knows not that an animal is to proceed from the egg, and far leſs that this animal muſt be nouriſhed with other animals, ſhe collects ten or twelve ſmall green worms, which ſhe piles one above another, rolls them up in a circular form, and fixes them in the hole in ſuch a manner that they cannot move. When the waſp-worm is hatched, it is amply ſtored with the food Nature has deſtined for its ſupport. The green worms are devoured in ſucceſſion*; and the number depoſited is exactly proportioned to the time neceſſary for the growth and transformation of the waſp-worm into a fly, when it iſſues from the hole, and is capable of procuring its own nouriſhment †.

There are many other inſtances of ichneumon waſps and flies, which, though they feed not themſelves upon worms, lay up proviſions of theſe animals for the nouriſhment of their young; and each kind is adapted to the conſtitution of the worm that is to proceed from their eggs §.

Birds of the ſame ſpecies, unleſs when reſtrained by peculiar circumſtances, uniformly build their neſts of the ſame materials, and in the ſame form and ſituation, though they inhabit very different climates. When removed by neceſſity from their eggs, they haſten back to them with anxiety. They turn and ſhift their eggs, which has the effect of heating them equally. Ducks and geeſe cover up their eggs till they return to the neſt. A hen ſits with equal ardour upon eggs of a different ſpecies, or even upon artificial eggs. I have often contemplated with wonder an inſtinct of the ſwallow. When her offſpring are very young, like other ſmall birds, ſhe carries their excrements out of the neſt. But, after they are older, ſhe attaches herſelf to the ſide of the neſt, and, by ſome geſtures and ſounds, ſolicits the young to void their excrements:

* Reaumur, tom. 12. pag. 18. S. † Ibid. pag. 22,—32. S.
§ Ibid. tom. 11. pag. 38. S.

crements: One of them immediately turns round, elevates its hind parts above the edge of the neſt, makes the proper effort, and the mother, before the dung is half protruded from the anus, lays hold of it with her bill, drags it out, carries it off, and drops it at a diſtance from the neſt. In all theſe operations, men recogniſe the intentions of Nature; but they are hid from the animals who perform them.

The ſpider, the dermeſtes, and many inſects of the beetle kind, exhibit an inſtinct of a very uncommon nature. When put in terror by a touch of the finger, the ſpider runs off with great ſwiftneſs: But, if he finds, that, whatever direction he takes, he is oppoſed by another finger, he then ſeems to deſpair of being able to eſcape, contracts his limbs and body, lies perfectly motionleſs, and counterfeits every ſymptom of death. In this ſituation I have pierced ſpiders with pins, and torn them to pieces, without their diſcovering the ſmalleſt mark of pain. This ſimulation of death has been aſcribed to a ſtrong convulſion, or ſtupor, occaſioned by terror. But this ſolution of the phænomenon is erroneous. I have repeatedly tried the experiment, and uniformly found, that, if the object of terror be removed, in a few ſeconds the animal runs off with great rapidity. Some beetles, when counterfeiting death, ſuffer themſelves to be gradually roaſted, without moving a ſingle joint.

It is unneceſſary to give more examples of pure inſtincts. I ſhall therefore proceed to the ſecond claſs, namely,

II. *Of Inſtincts which can accommodate themſelves to peculiar circumſtances and ſituations.*

To this claſs many human inſtincts may be referred. But, as theſe inſtinctive propenſities are likewiſe highly improveable by experience and obſervation, examples of them will fall more naturally to be given under the third claſs.

Thoſe animals are moſt perfect whoſe ſphere of knowledge extends to the greateſt number of objects. When

interrupted in their operations, they know how to resume their labours, and to accomplish their purposes, by different means. Some animals have no other power but that of contracting or extending their bodies. But the falcon, the dog, and the fox, pursue their prey with intelligence and address.

The ostrich has been accused of unnaturalness, because she leaves her eggs to be hatched by the heat of the sun. In Senegal, where the heat is great, she neglects her eggs during the day, but sits upon them in the night. At the Cape of Good-Hope, however, where the degree of heat is less, the ostrich, like other birds, sits upon her eggs both day and night.

Rabbits dig holes in the ground for warmth and protection. But, after continuing long in a domestic state, that resource being unnecessary, they seldom employ this art *.

Bees, when they have not room enough for their operations, augment the depth of their honey-cells †. The female bee, when the cells are not sufficiently numerous to receive her eggs, lays two or three in each cell. But, a few days after, when the cells are increased, the working bees remove all the supernumerary eggs, and deposit them in the new constructed cells ‡.

When a wasp, in attempting to transport a dead companion from the nest, finds the load too heavy, he cuts off its head, and carries it out in two portions §.

In countries infested with monkeys, many birds, which, in other climates, build in bushes and the clefts of trees, suspend their nests upon slender twigs, and, by this ingenious device, elude the rapacity of their enemies.

The nymphs of water-moths, commonly called *cod-bait*, cover themselves, by means of gluten, with pieces of wood, straw, small shells, or gravel. It is necessary that they should always be nearly in equilibrium with the water in which they live. To accomplish this purpose, when their habitations are too heavy, they add a piece of wood, when too light, a bit of gravel ‖.

I had

* Gazette Liter. tom. 3. pag. 228. S.
† Reaumur, tom. 10. pag. 29. S.
‡ Ibid. pag. 240. S.
§ Ibid. tom. 11. pag. 241. S.
‖ Bonnet, tom. 4. pag. 209.——Reaumur, tom. 5. pag. 215. S.

I had a cat that frequented a closet, the door of which was fastened by a common iron latch. A window was situated near the door. When the door was shut, the cat gave herself no uneasiness. As soon as she tired of her confinement, she mounted on the sole of the window, and with her paw dexterously lifted the latch and came out. This practice she continued for years.

These examples, I hope, are sufficient.

III. *The third class comprehends all those Instincts which are improveable by experience and observation.*

The superiority of man over the other animals seems to depend chiefly on the great number of instincts with which his mind is endowed. Traces of every instinct he possesses are discoverable in the brute creation. But no particular species enjoys the whole. On the contrary, most animals are limited to a small number. This appears to be the reason why the instincts of brutes are stronger, and more steady in their operation, than those of man. A being actuated by a great variety of motives must necessarily reason, or, in other words, hesitate in his choice. Its conduct, therefore, must often waver; and he will have the appearance of being inferior to another creature who is stimulated to action by a smaller number of motives. Man, accordingly, has been considered as the most vacillant and inconsistent of all animals. The remark is just; but, instead of a censure, it is an encomium on the species. The actions of a dog, or a monkey, for the same reason, are more various, whimsical, and uncertain, than those of a sheep or a cow.

Most human instincts receive improvement from experience and observation, and are capable of a thousand modifications. This is another source of man's superiority over the brutes. When we are stimulated by a particular instinct, instead of instantly obeying the impulse, another instinct arises in opposition, creates hesitation, and often totally extinguishes the original motive to action. The instinct of fear is daily counteracted by ambition or resentment; and, in some minds, fear is too powerful

powerful for resentment, or any other instinct we possess. The instinct of anger is often restrained by the apprehension of danger, by the sense of propriety, by contempt, and even by compassion. Sympathy, which is one of our most amiable instincts, frequently yields to anger, ambition, and other motives. The instinct or sense of morality is too often thwarted by ambition, resentment, love, fear, and several of what I call modified or compounded instincts, such as avarice, envy, &c.

The following are examples of modified, compounded, or extended instincts.

Superstition is the instinct of fear extended to imaginary objects of terror.

Devotion is an extension of the instinct of love to the First Cause, or Author of the Universe.

Reverence or respect for eminent characters is a species of devotion.

Avarice is the instinct of love directed to an improper object.

Hope is the instinct of love directed to future good.

Envy is compounded of love, avarice, ambition, and fear.

Benevolence is the instinct of love diffused over all animated beings.

Sympathy is the instinct of fear transferred to another person, and reflected back upon ourselves.

In this manner, all the modified, compounded, or extended passions and propensities of the human mind, may be traced back to their original instincts.

The instincts of brutes are likewise improved by observation and experience. A young dog, like a child, requires both time and art to unfold and perfect his natural instincts. If neglected by man, he learns from his companions how to act in particular situations: But, when he enjoys both these sources of information, his talents are improved to a degree that often excites our astonishment. The same remark applies to all docile animals, as the elephant, the horse, the camel, &c. Every man's recollection will supply him with many examples of the improveable talents of brutes; and, therefore, it is unnecessary to be more explicit.

Having

Having exhibited inſtances of pure inſtinct, of inſtincts which accommodate themſelves to peculiar circumſtances and ſituations, and of inſtincts improveable by obſervation and experience, I ſhall now hazard a few remarks.

From the examples I have given, it appears that inſtinct is an original quality of mind, which, in many animals, may be improved, modified, and extended, by experience; that ſome inſtincts are coeval with birth; and that others, as fear, anger, the principle of imitation, and the power of reaſoning, or balancing motives, are gradually unfolded, according to the exigencies of the animal. One of the ſtrongeſt inſtincts appears not till near the age of puberty; but, by bad example, and improper ſituations, this inſtinctive deſire is often prematurely excited. The minds of brutes, as well as thoſe of men, have original qualities, deſtined for the preſervation of the individual, and the continuation of the ſpecies. The calling forth of theſe qualities is not inſtinct, but the exertion or energy of inſtinct. Inſtincts exiſt before they act. What man or brutes learn by experience, though this experience be founded on inſtinct, cannot with propriety be called inſtinctive knowledge, but knowledge derived from experience and obſervation. Inſtinct ſhould be limited to ſuch actions as every individual of a ſpecies exerts without the aid either of experience or imitation. Hence inſtinct may be defined, 'Every original quality of mind which produces particular feelings or actions, when the proper 'objects are preſented to it.' Theſe qualities or inſtincts vary in particular ſpecies. Some are endowed with many, and others with few. In ſome they are ſtronger, in others weaker; and their ſtrength or weakneſs ſeems to be exactly proportioned to their number. The difference of talents among men who have had the ſame culture, ariſes from a bluntneſs, or abſolute deprivation, of ſome original or modified inſtincts. Taſte, or love of particular objects, whether animated, inanimated, or artificial, is in ſome men ſo obtuſe, that we often ſay it is entirely wanting. Inſects have fewer inſtincts than men or quadrupeds; but the exertions of inſects are ſo uniform and ſteady, that they excite the admiration of every beholder.

Senſation implies a ſentient principle, or mind. Whatever feels, therefore, is mind. Of courſe, the loweſt ſpecies of animals are endowed with mind: But, the minds of animals have very different powers; and theſe powers are expreſſed by peculiar actions. The ſtructure of their bodies is uniformly adapted to the powers of their minds. We never ſee a mature animal attempting actions which Nature has not enabled it to perform, by beſtowing on it proper inſtruments. A bee collects the materials of honey and wax, but attempts not to gnaw rotten wood, like the waſp.—Neither does peculiarity of ſtructure prompt the actions of brutes. Calves puſh with their heads long before their horns are grown. This, and ſimilar examples, ſhow, that the inſtincts of brutes exiſt previous to the expanſion of thoſe inſtruments which Nature intended they ſhould employ.

This view of inſtinct is ſimple, removes every objection to the exiſtence of mind in brutes, and unfolds all their actions, by referring them to motives perfectly ſimilar to thoſe by which man is actuated. There is, perhaps, a greater difference between the mental powers of ſome animals than between thoſe of man and the moſt ſagacious brutes. Inſtincts may be conſidered as ſo many internal ſenſes, of which ſome animals have a greater, and others a ſmaller number. Theſe ſenſes, in different ſpecies, are likewiſe more or leſs ductile; and the animals poſſeſſing them are, of courſe, more or leſs ſuſceptible of improving, and of acquiring knowledge.

The notion that animals are machines, is perhaps too abſurd to merit refutation. Though no animal is endowed with mental powers equal to thoſe of man, yet there is not a faculty of the human mind, but evident marks of its exiſtence are to be found in particular animals. Senſes, memory, imagination, the principle of imitation, curioſity, cunning, ingenuity, devotion, or reſpect for ſuperiors, gratitude, are all diſcoverable in the brute creation. Neither is art denied to them. They build in various ſtiles; they dig; they wage war; they extract peculiar ſubſtances from water, from plants, from the earth; they modulate their voices ſo as to communicate their wants,

wants, their ſentiments, their pleaſures and pains, their apprehenſions of danger, and their proſpects of future good. Every ſpecies has its own language, which is perfectly underſtood by the individuals. They aſk and give aſſiſtance to each other. They ſpeak of their neceſſities; and this branch of their language is more or leſs extended, in proportion to the number of their wants. Geſtures and inarticulate ſounds are the ſigns of their thoughts. It is neceſſary that the ſame ſentiments ſhould produce the ſame ſounds and the ſame movements; and, conſequently, each individual of a ſpecies muſt have the ſame organization. Birds and quadrupeds, accordingly, are incapable of holding diſcourſe to each other, or communicating the ideas and feelings they poſſeſs in common. The language of geſture prepares for that of articulation; and ſome animals are capable of acquiring a knowledge of articulate ſounds. They firſt judge of our thoughts by our geſtures; and afterwards acquire the habit of connecting theſe thoughts with the language in which we expreſs them. It is in this manner that the elephant and the dog learn to obey the commands of their maſters.

Infants are exactly in the ſame condition with brutes. They underſtand ſome of our geſtures and words long before they can articulate. They diſcover their wants by geſtures and inarticulate ſounds, the meaning of which the nurſe learns by experience. Different infants have different modes of expreſſing their wants. This is the reaſon why nurſes know the intentions of infants, though they are perfectly unintelligible to ſtrangers. When an infant, accordingly, is transferred from one nurſe to another, the former inſtructs the latter in the geſtures and inarticulate language of the child.

The idea of a *machine* implies a ſelect combination of the common properties of matter. The regularity of its movements is a proof that they are totally diſtinct from animal or ſpontaneous motion. A machine has nothing analogous to ſenſation, which is the loweſt characteriſtic of an animal. An *animated machine*, therefore, is an abſurd abuſe of terms. It confounds what Nature has diſtinguiſhed in the moſt unambiguous manner. The in-

ſtincts

ſtincts of brutes, are, in general, ſtronger, and leſs ſubject to reſtraint, than thoſe of man. The reaſon is plain: They have not an equal number of inſtincts to curb, counterbalance, or moderate their motives to particular actions. Hence they have often the appearance of acting by mere impulſe; and this circumſtance has led ſome philoſophers to conſider brutes as machines. But they reflect not that children, ſavages, and ignorant men, act nearly in the ſame manner. It is ſociety and culture which ſoften and moderate the paſſions and actions of men, as well as of thoſe of docile animals.

Brutes, like men, learn to ſee objects in their proper poſition, to judge of diſtances and heights, and of hurtful, pleaſureable, or indifferent bodies. Without ſome portion of reaſon, therefore, they could never acquire the faculty of making a proper uſe of their ſenſes. A dog, though preſſed with hunger, will not ſeize a piece of meat in preſence of his maſter, unleſs it be given to him: But, with his eyes, his movements, and his voice, he makes the moſt humble and expreſſive petition. If this balancing of motives be not reaſoning, I know not by what other name it can be called.

Animals, recently after birth, know not how to avoid danger. Neither can they make a proper uſe of their members. But experience ſoon teaches them what is pleaſant and what is painful, what objects are hurtful and what ſalutary. A young cat, or a dog, who has had no experience of leaping from a height, will, without heſitation, precipitate itſelf from the top of a high wall. But, after perceiving that certain heights are hurtful, and others inoffenſive, the animal learns to make the diſtinction, and never afterwards can be prevailed upon to leap from a height which it knows will be productive of pain.

Young animals examine every object they meet with. In this inveſtigation they employ all their organs. The firſt periods of their life are dedicated to ſtudy. When they run about, and make frolickſome gambols, it is Nature ſporting with them for their inſtruction. In this manner they improve their faculties and organs, and acquire an intimate knowledge of the objects which ſurround

round them. Men who, from peculiar circumſtances, have been prevented from mingling with companions, and engaging in the different amuſements and exerciſes of youth, are always awkward in their movements, cannot uſe their organs with eaſe or dexterity, and often continue, during life, ignorant of the moſt common objects.

From the above facts and reaſoning, it ſeems to be apparent, that inſtincts are original qualities of mind; that every animal is poſſeſſed of ſome of theſe qualities; that the intelligence and reſources of animals are proportioned to the number of inſtincts with which their minds are endowed; that all animals are, in ſome meaſure, rational beings; and that the dignity and ſuperiority of the human intellect are neceſſary reſults, not of the conformation of our bodies, but of the great variety of inſtincts which Nature has been pleaſed to confer on the ſpecies.

CHAPTER VI.

Of the Senſes.

NO animal of which we have any knowledge is endowed with more than the five external ſenſes of ſmelling, taſting, hearing, touch, and ſeeing; and no animal, however imperfect, is deſtitute of the whole. Without organs of ſenſation, in a ſmaller or greater number, animal or intellectual exiſtence is to us an inconceivable idea. Hence the notion of the ancients, and of a very few moderns, that this earth, as well as all the heavenly bodies, are intelligent beings, though they have not the veſtige of any inſtrument of ſenſation, or of any thing analogous to our ideas of animation, except mechanical motion, is too abſurd even to be ſeriouſly mentioned.

Upon this intereſting ſubject, as it comprehends every ſource of information, and every motive to action in man, as

as well as in the inferior animals, it is not ſurpriſing that ſo much has been written, and that ſo many different theories have been invented, and ſubmitted to public inſpection. Some of theſe theories ſhall be taken notice of in a curſory manner, and others, as unworthy of attention, ſhall be paſſed over in ſilence.

Our obſervations on the different inſtruments of ſenſation ſhall proceed in the following order, namely, of the ſenſes of ſmelling, of taſting, of hearing, of touch, and of ſeeing. In general, it may be remarked, that all ſenſation is conveyed to the mind by an unknown influence of the nerves. If the optic, olfactory, or any nerve diſtributed over an organ of ſenſation, be cut, or rendered paralytic, the animal inſtantly loſes that particular ſenſe. This is a fact univerſally eſtabliſhed by experiment. But that the nerves, which are perfectly ſimilar in every part of the body, ſhould, when diſtributed over the eye, the ear, the tongue, the noſe, convey to the mind feelings ſo different, is the moſt myſterious part of this ſubject. When M. de Bonnet tells us, that every organ of ſenſe probably conſiſts of fibres ſpecifically different; and that theſe fibres are particular ſenſes endowed with a peculiar manner of acting, correſponding to the perceptions they excite in the mind;—he means to reaſon; but he does no more than give a circumlocution for the fact.

OF SMELLING.

In man, and many other animals, the organ by which the ſenſe of ſmelling is conveyed to the mind has received the general appellation of *noſe*, or *noſtrils*. The more immediate inſtrument of this ſenſation is a ſoft, vaſcular, porous membrane, covered with numerous papillæ, and is known by the name of *membrana pituitaria*, or *membrana Schneideriana*. This membrane is totally covered with infinite ramifications and convolutions of the olfactory nerves. Theſe nerves are almoſt naked, and expoſed to the action of the air which paſſes through the noſe in performing the function of reſpiration. But Nature, ever

attentive

attentive to the eaſe and convenience of her creatures, has furniſhed the noſtrils with a number of glands, or ſmall arteries, which ſecrete a thick inſipid mucus. By this mucus, the olfactory nerves are defended from the action of the air, and from the painful ſtimuli of acrid odours.

The odours perceived by ſmelling are extremely various. Some of them convey to us the moſt delightful and refreſhing ſenſations, and others are painful, noxious, and diſguſting. All bodies in Nature, whether ſolid or fluid, whether animated or inanimated, continually ſend forth to the air certain effluvia or emanations from their reſpective ſubſtances. Theſe effluvia float in the atmoſphere, and act upon the olfactory nerves of different animals, and ſometimes of different individuals of the ſame ſpecies, in ſuch a manner as to produce very different ſenſations. What is pleaſant to the noſtrils of one animal is highly offenſive to thoſe of another. Brute animals ſelect their food chiefly by employing the ſenſe of ſmelling, and it ſeldom deceives them. They eaſily diſtinguiſh noxious from ſalutary food; and they carefully avoid the one, and uſe the other for nouriſhment. The ſame thing happens with regard to the drink of animals. A cow, when it can be obtained, always repairs to the cleareſt and freſheſt ſtreams; but a horſe, from ſome inſtinctive impulſe, uniformly raiſes the mud with his feet, and renders the water impure, before he drinks.

In the ſelection of food, men are greatly aſſiſted, even in the moſt luxurious ſtate of ſociety, by the ſenſe of ſmelling. By ſmelling we often reject food as noxious, and will not riſk the other teſt of taſting. Victuals which have a putrid ſmell, as equally offenſive to our noſtrils as hurtful to our conſtitutions, we avoid with abhorrence; but we are allured to eat ſubſtances which have a grateful and ſavoury odour. The more frequent and more acute diſcernment of brutes in the exerciſe of this ſenſe, is entirely owing to their freedom, and to their uſing natural productions alone. But men in ſociety, by the arts of cookery, by the unnatural aſſemblage of twenty ingredients in one diſh, blunt, corrupt, and deceive both their ſenſes

ſenſes of ſmelling and taſting. Were we in the ſame natural condition as the brutes, our ſenſe of ſmelling would enable us to diſtinguiſh, with equal certainty, noxious from ſalutary food. Brutes, as well as men, prefer particular foods to others. This may be conſidered as a ſpecies of luxury; but it ſhould likewiſe be conſidered, that all the articles they uſe are either animal or vegetable ſubſtances in a natural ſtate, neither converted into a thouſand forms and qualities by the operation of fire and water, nor having their ſavour exalted by ſtimulating condiments. Domeſtic animals are nearly in the ſame condition with luxurious men. A pampered dog ſnuffs and rejects many kinds of food, which, in a natural ſtate, he would devour with eagerneſs.

It is not unworthy of remark, that, in all animals, the organs of ſmelling and of taſting are uniformly ſituated very near each other. Here the intention of Nature is evident. The vicinity of theſe two ſenſes forms a double guard in the ſelection of food. Were they placed in diſtant parts of the body, they could not ſo readily give mutual aid to one another.

But aſſiſtance in the choice of food is not the only advantage that men and other animals derive from the ſenſe of ſmelling. Every body in nature, whether animal, or mineral, when expoſed to the air, continually ſends forth emanations, or effluvia, of ſuch extreme ſubtilty, that no eye can perceive them. Theſe effluvia, or volatile particles, diffuſe themſelves through the air, and moſt of them are recogniſed, by the organ of ſmelling, to be either agreeable or diſagreeable. To give ſome idea of the inconceivable minuteneſs of theſe particles, and of the amazing ſenſibility of the noſtrils of animals, the odour of muſk has been known to fill a large ſpace for ſeveral years without loſing any perceptible part of its weight. Thus, the air we breathe is perpetually impregnated with an infinity of different particles which ſtimulate the olfactory nerves, and give riſe to the ſenſation of ſmell. When our ſenſes are not vitiated by unnatural habits, they are not only faithful monitors of danger, but convey to us the moſt exquiſite pleaſures. Even the ſenſe of ſmelling

ing is always productive either of pleaſure or pain. The fragrance of a roſe, and of many other flowers, is not only pleaſant, but gives a refreſhing and delightful ſtimulus to the whole ſyſtem, and may be conſidered as a ſpecies of wholeſome nouriſhment; while the odours proceeding from hemlock, and from many other noxious vegetable, animal, and mineral ſubſtances, are highly offenſive to our noſtrils. Hence we are naturally compelled to embrace the one claſs of ſenſations and to avoid the other.

Some animals, as the dog, the fox, the raven, &c. are endowed with a moſt exquiſite ſenſe of ſmelling. A dog ſcents various kinds of game at conſiderable diſtances; and, if the fact were not confirmed by daily experience, it could hardly gain credit, that he can trace the odour of his maſter's foot through all the winding ſtreets of a populous city. If we judge from our own feelings, this extreme ſenſibility in the noſe of a dog is to us perfectly incomprehenſible.

The ſenſe of ſmelling, like that of ſome other ſenſes, may be perverted or corrupted by habit. The ſnuffing, chewing, and ſmoaking tobacco, though at firſt diſagreeable, become, by the power of habit, not only pleaſant, but almoſt indiſpenſible. The ſame remark is applicable to the practice of ſwallowing ardent ſpirits, the moſt deleterious of all poiſons, becauſe the moſt extenſively employed. How the natural ſtate of the nerves, and of the ſenſations conveyed by them, ſhould be ſo completely changed, we are totally ignorant. The conſtitution of the nerves often varies in different individuals of the ſame ſpecies. An odour which is diſguſtful to one man is highly grateful to another. I knew a gentleman who was in the daily habit of lighting and putting out candles, that he might enjoy the pleaſure of their ſmell. Few men, I ſuppoſe, would envy him.

OF TASTING.

The tongue and palate are the great inſtruments of this ſenſation. With much wiſdom and propriety, the organ of taſte is ſituated in ſuch a manner as enables it to be a guardian to the alimentary canal, and to aſſiſt the organ of ſmell in diſtinguiſhing ſalutary from noxious food. The tongue, like the other inſtruments of ſenſation, is amply ſupplied with nerves. The terminations of theſe nerves appear on the ſurface of the tongue in the form of *papillæ*, or minute nipples, which are always erected on the application of ſapid or ſtimulating ſubſtances. This elevation and extenſion of the papillæ, by bringing larger portions of the nerves into contact with the ſubſtances applied to the tongue, give additional ſtrength to the ſenſation, and enable us to judge with greater accuracy concerning their nature and qualities. Beſide the nervous papillæ, the tongue is perpetually moiſtened with ſaliva, a liquor which, though inſipid itſelf, is one great cauſe of all taſtes. The ſaliva of animals is a very powerful ſolvent. Every ſubſtance applied to the tongue is partially diſſolved by the ſaliva before the ſenſation of taſte is excited. When the tongue is rendered dry by diſeaſe, or any other cauſe, the ſenſe of taſte is either vitiated or totally annihilated.

In ſome men, the ſenſe of taſte is ſo blunt, that they cannot diſtinguiſh, with any degree of accuracy, the different ſpecies of that ſenſation. In others, whether from Nature or from habit, this ſenſe is ſo acute, that they can perceive the niceſt diſtinctions in the ſavour of ſolids and of liquids.

The ſenſations conveyed to the mind by taſte, like thoſe of all the ſenſes, are either agreeable, diſagreeable, or indifferent. The pleaſures ariſing from this ſenſe are not only great, but highly uſeful to every animal. The ſenſe itſelf, however, is comparatively groſs; for, in ſmelling, hearing, and ſeeing, ſenſations are excited by emanations or undulations proceeding from bodies at great diſtances

from

from the animals who perceive them. But, in tasting, the object must be brought into actual contact with the tongue before its qualities can be discovered. How this proportionally gross sense should have been selected, and figuratively applied to the general perception of every thing beautiful and sublime, whether in Nature or in art, it is difficult to determine. The inquiry, however, would not be incurious, whether men who have an obtuse sense of tasting material substances are likewise deficient in the perception of beauty and deformity.

Though the sense of taste varies in some individuals, yet, like figurative taste, the standard of agreeable and disagreeable, of pleasant and painful, is almost universally diffused over mankind and the brute creation. Every horse, and every ox, when in a natural state, eat and reject the same species of food. But, men in society, as well as domestic animals, are induced by habit, by necessity, or by imitation, to acquire a taste for many dishes, and combinations of substances, which, before the natural discriminating sense is perverted, would be rejected with disgust.

Some individuals of the human species have an aversion to particular kinds of food, which are generally agreeable. This aversion may be either original or acquired. I knew a child, who, from the moment he was weaned, could never be induced to take milk of any kind. These original aversions must be ascribed to some peculiar modification in the structure of the organ, or in the dispoposition of its nerves. But, in general, disgust at particular foods is produced by surfeits, which injure the stomach, and create, in that exquisitely-irritable viscus, an insuperable antipathy to receive nourishment which formerly gave it so much uneasiness to digest.

Brute animals, especially those which feed upon herbage, and are not liable to be corrupted by example or necessity, distinguish tastes with wonderful accuracy. By the application of the tongue, they instantly perceive whether any plant is salutary or noxious. To enable them, amidst a thousand plants, to make this discrimina-

tion,

tion, their nervous papillæ, and their tongues, are proportionally much larger than thofe of man.

OF HEARING.

THE fenfation of hearing is conveyed to the mind by undulations of air ftriking the ear, an organ of a very delicate and complex ftructure. In man and quadrupeds, the external ears are large, and provided with mufcles by which they can erect and move them from fide to fide, in order to catch the undulations produced in the air by the vibrations of fonorous bodies, or to diftinguifh with greater accuracy the fpecies of found, and the nature and fituation of the animal or object from which it proceeds. Though the human ears, like thofe of quadrupeds, are furnifhed with mufcles, evidently intended for fimilar movements, yet, I know not for what reafon, there is not one man in a million who has the power of moving his ears. When we liften to a feeble found, we are confcious of an exertion; but that exertion, and the motions produced by it, are confined to the internal parts of the organ.

The canals or paffages to the internal parts of the ear are cylindrical, fomewhat contorted, and become gradually fmaller till they reach the *membrana tympani*, which covers what is called the drum of the ear. This membrane, which is extremely fenfible, when acted upon by undulations of air, however excited, conveys, by means of a complex apparatus of bones, nerves, &c. the fenfation of found to the brain or fentient principle.

That air is the medium by which all founds are propagated, has been eftablifhed by repeated experiments. The found of a bell, fufpended in the receiver of an air-pump, gradually diminifhes as the air is exhaufted, till it almoft entirely ceafes to be heard. On the other hand, when the quantity of air is increafed by a condenfer, the intenfity of the found is proportionally augmented. Mr. Haukfbee, in a paper publifhed in the Philofophical Tranfactions, has proved, that founds actually produced cannot be

be tranſmitted through a *vacuum*, or a ſpace deprived of air. 'I took,' ſays he, 'a ſtrong receiver, armed with a 'braſs hoop at the bottom, in which I included a bell as 'large as it could well contain. This receiver I ſcrewed 'ſtrongly down to a braſs plate with a wet leather be- 'tween, and it was full of common air, which could 'nowiſe make its eſcape. Thus ſecured, it was ſet on 'the pump, where it was covered with another large re- 'ceiver. In this manner, the air contained between the 'outward and inward receivers was exhauſted. Now here 'I was ſure, when the clapper ſhould be made to ſtrike 'the bell, there would be actually ſound produced in the 'inward receiver; the air in which was of the ſame den- 'ſity as common air, could ſuffer no alteration by the '*vacuum* on its outſide, ſo ſtrongly was it ſecured on all 'parts. Thus, all being ready for trial, the clapper was 'made to ſtrike the bell; but I found that there was no 'tranſmiſſion of it through the *vacuum*, though I was 'ſure there was actual ſound produced in the inward re- 'ceiver.'

To enable us to underſtand the manner in which ſounds are propagated through the air, philoſophers have had recourſe to the undulations produced by a ſtone thrown into a pond of ſtagnating water. Theſe undulations aſſume the form of circular waves, which ſucceſſively proceed from the place where the ſtone ſtruck the water, as from a center, and continually dilate, and become greater and greater as they recede from that center, till they reach the banks of the water, where they either vaniſh or are reflected. Now, as air is likewiſe a fluid, ſimilar undulations, though to us inviſible, are produced in it by the vibrations of ſonorous bodies, and are alſo propagated to great diſtances in ſucceſſive waves or rings. Theſe undulations of the air, when they come into contact with our organs of hearing, make ſuch a tremulous impreſſion upon them as excites in our minds the ſenſation of ſound. This analogy, though not altogether perfect, is ſufficient to illuſtrate thoſe inviſible motions of the air by which ſounds are conveyed from one place to another, and to give

give an idea of echoes, or reflected undulations of that fluid.

The celerity with which sounds, or undulations of air, move, has been exactly computed. All sounds, whether acute or grave, strong or weak, move at the rate of 1142 feet in a second of time. Hence, whenever the lightening of thunder, or the fire of artillery, are seen, their actual distances from the observer may be easily ascertained by the vibrations of a pendulum. This velocity, it is true, may be a little augmented or diminished by favourable or by contrary winds, and by heat or cold. But the difference, even in high winds, is so trifling, that, for any useful purpose, it scarcely merits attention.

Infants hear bluntly, because the bones of their ears are soft and cartilaginous; and, of course, the tremulations excited in them by the motions of the air are comparatively weak. Young children, accordingly, are extremely fond of noise. It rouses their attention, and conveys to them the agreeable sensation of sound; but feeble sounds are not perceived, which gives infants, like deaf persons, the appearance of inattention, or rather of stupidity.

The force or intensity of sound is augmented by reflection from surrounding bodies. It is from this cause that the human voice, or any other noise, is always weaker, and less distinctly heard, in the open air than in a house.

The modifications of sound are not less various than those of tastes or odours. The ear is capable of distinguishing some hundred tones in sound, and probably as many degrees of strength in the same tones. By combining these, many thousand simple sounds, which differ either in tone or in strength, are perceived and distinguished by the ear. A violin, a flute, a French-horn, may each of them give the same tone; but the ear easily makes the distinction. The immense variety of sensations, arising from the organs of smelling, of tasting, and of hearing, enables animals to judge concerning the nature and situation of external objects. By habit we learn to know the bodies from which particular species of sounds proceed. Previous to all experience, we could not distinguish whether a sound

a ſound came from the right or the left, from above or below, from a greater or a ſmaller diſtance, or whether it was the ſound of a coach, of a drum, of a bell, or of an animal. By catching cold, I once had a temporary deafneſs in my left ear. I was ſurpriſed to find that I had loſt the faculty of perceiving the ſituation from which ſounds proceeded. If a dog barked on the left, I thought the noiſe came from the right. This circumſtance excited my curioſity: But, upon recollection, I knew that my left ear was deaf; and that every ſound I heard was perceived ſolely by the right; and, conſequently, I diſcovered the cauſe of the deception.

Hearing enables us to perceive all the agreeable ſenſations conveyed to our minds by the melody and harmony of ſounds. This, to man at leaſt, is a great ſource of pleaſure and of innocent amuſement. But ſome men are almoſt totally deſtitute of the faculty of diſtinguiſhing muſical ſounds, and of perceiving thoſe delightful and diverſified feelings excited by the various combinations of muſical tones. Moſt men derive pleaſure from particular ſpecies of muſic. But, a muſical ear, in a reſtricted ſenſe, is by no means a general qualification. An ear for muſic, however, though not to be acquired by ſtudy, when the faculty itſelf is wanting, may be highly improved by habit and culture. Buffon, after examining a number of perſons who had no ear for muſic, ſays, that every one of them heard worſe in one ear than in the other; and aſcribes their inability of diſtinguiſhing muſical expreſſion to that defect. But a muſical ear ſeems to have no dependence on acuteneſs or bluntneſs of hearing, whether in one or in both ears. There are many examples of people who may be ſaid to be half deaf, and yet are both fond of muſic, and ſkilful practitioners. An ear for muſic, like a genius for painting or poetry, is a gift of Nature, and is born with the poſſeſſor.

Beſide the innumerable pleaſures we derive from muſic and agreeable ſounds, the extenſion and improvement of *artificial* language muſt be conſidered as objects of the greateſt importance to the human race. Without the ſenſe of hearing, mankind would forever have remained mute.

mute. I mention *artificial*, or improved, language, becauſe, from a thouſand obſervations which every perſon muſt have made, it is perfectly apparent, that, if deſtitute of a *natural* language, neither man nor the brute creation * could poſſibly have exiſted and continued their ſpecies. As brutes, without information or experience, are capable of communicating to each other, by particular ſounds and geſtures, their pleaſures and pains, their wants and deſires, it would be the higheſt abſurdity to ſuppoſe that the great Creator ſhould have denied to man, the nobleſt animal that inhabits this globe, the ſame indiſpenſible privilege. Without a baſis there can be no fabric. Without a *natural* no *artificial* language could poſſibly have exiſted. This point is clearly demonſtrated, in a few words, by that moſt ingenious, candid, and profound philoſopher, Dr. Thomas Reid, Profeſſor of Moral Philoſophy in the Univerſity of Glaſgow. 'If mankind,' ſays Dr. Reid, 'had not a *natural* language, they could 'never have invented an artificial one by their reaſon and 'ingenuity. For all artificial language ſuppoſes ſome 'compact or agreement to affix a certain meaning to certain ſigns; therefore, there muſt be compacts or agreements before the uſe of artificial ſigns; but there can 'be no compact or agreement without ſigns, nor without 'language; and therefore there muſt be a natural language before any artificial language can be invented †. Let any man try to overturn this argument, which is founded, not upon *metaphyſical* conjecture, but upon the ſolid baſis of *fact* and uncontrovertible *reaſoning*. The elements, or conſtituent parts of the natural language of mankind, the Doctor reduces to three kinds; modulations of the voice, geſtures, and features. 'By means of 'theſe,' ſays he, 'two ſavages, who have no common 'artificial language, can converſe together; can communicate their thoughts in ſome tolerable manner; can aſk 'and refuſe, affirm and deny, threaten and ſupplicate; 'can traffic, enter into covenants, and plight their faith.'

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* Concerning the language of beaſts, I ſhall, perhaps, be more explicit in a future work. S.

† Doctor Reid's Inquiry into the Human Mind, on the Principles of Common Senſe, pag. 93. S.

I can perceive only one plausible objection to this reasoning. If, it may be said, man were endowed with a natural language, this language must be universal; from what source, then, can the great diversity of languages in different nations, and tribes of the human race, be derived? The solution of this question depends not upon metaphysical arguments, but upon fact and experience. I have had considerable opportunities of observing the behaviour of children. Infants, when very young, have nearly the same modes of expressing their pleasures and pains, their desires and aversions. These they communicate by voice, gesture, and feature; and every infant, whatever be the country, climate, or language, uniformly expresses its feelings almost in the same manner. But, when they arrive at nine or twelve months of age, a different scene is exhibited. They then, beside the general expressions of feeling and desire, attempt to give names to particular objects. Here artifice begins. In these attempts, previous to the capacity of imitating articulate sounds, every individual infant utters different sounds, or rather gives different names, to signify the same objects of its desire or aversion. Beside this natural attempt towards a nomenclature, infants, during the period above mentioned (for the time varies according to the health and vivacity of the child), frequently make continued orations. These orations consist both of articulate and inarticulate sounds, of which no man can give an idea in writing. But most men, and every woman who has nursed children, will perfectly understand what I cannot express. From the fact, that children actually utter different sounds, or give different names to denote the same objects, I imagine, arises all that diversity of languages, which, by exhausting time and attention, retard the progress and improvement both of Art and Science. If any number of children, or of solitary savages, should chance to associate, the names of objects would soon be settled by imitation and consent. By observation and experience the number of names would be augmented, as well as the qualities or attributes of the objects themselves; and, in the progress of time, a new and artificial language would

be gradually formed. While this operation is going on in one corner of a country, twenty ſimilar aſſociations and compacts may be forming, or already formed, in different nations, or in different diſtricts of the ſame nation, all of which would give birth to ſeparate artificial languages.

OF TOUCH.

The ſenſations of ſmelling, taſting, hearing, and ſeeing, are conveyed to us by partial organs, which are all confined to the head. But the ſenſe of touching, or of feeling, is not only common to theſe organs, but extends over almoſt every part of the body, whether external or internal. Though every ſenſation may be comprehended under the general appellation of *feeling*, yet what is called the ſenſe of *touch* is properly reſtricted to the different ſenſations excited by bodies applied to the ſkin, and particularly to the tips of the fingers.

With regard to ſenſation in general, it is worthy of remark, that the eyes, the ears, the noſtrils, the tongue and palate, the palms of the hands, eſpecially towards the points of the fingers, are more amply ſupplied with nerves than any other external parts of the body. The terminations of the nerves on the ſurface of the ſkin are ſoft and pulpy, and form minute protuberances reſembling the nap of freeze-cloth, though greatly inferior in magnitude. Theſe protuberances have received the denomination of *nervous papillæ*. They might be called *animal feelers*; for they are obviouſly the immediate inſtruments of ſenſation. If an object be preſented to the eye, or any other organ of ſenſation, certain feelings are excited, which are either agreeable or diſagreeable, according to the real or imaginary qualities which we conſider as belonging to that object. The feelings thus excited inſtantly produce a change in the ſenſitive organs by which they are occaſioned. If the object be poſſeſſed of diſagreeable qualities, averſion is the neceſſary conſequence. But, if beauty and utility are perceived in the object,

object, pleaſant emotions ſpring up in the mind, which naturally induce a ſimilar tone or diſpoſition in the organs ſuited for the enjoyment of theſe qualities.

When examining or enjoying any object, it is natural to inquire, what are the changes produced in the nervous papillæ, or organs of ſenſation? If an object poſſeſſed of agreeable feelings is perceived, the nervous papillæ inſtantly extend themſelves, and, from a ſtate of flaccidity, become comparatively rigid like briſtles. This extenſion of the papillæ is not conjectural: It is founded on anatomical obſervation, and, in ſome caſes, may be ſeen and felt by perſons of acute and diſcerning ſenſations. When a man in the dark inclines to examine any ſubſtance, in order to diſcover its figure, or other qualities, he perceives a kind of rigidity at the tips of his fingers. If the fingers are kept long in this ſtate, the rigidity of the nervous papillæ will give him a kind of pain or anxiety, which it is impoſſible to deſcribe. The cauſe of this pain is an over-diſtenſion of the papillæ. If a ſmall inſect creeps on a man's hand, when the papillæ are flaccid, its movements are not perceived: But, if he happens to direct his eye to the animal, he immediately extends his papillæ, and feels diſtinctly all its motions. If a body be preſent, which, in the common ſtate of the nerves, has ſcarcely any ſenſible odour, by extending the papillæ of the noſtrils, an agreeable, diſagreeable, or indifferent ſmell will be perceived. When two perſons are whiſpering, and we wiſh to know what is ſaid, we ſtretch the papillæ, and other organs of hearing, which are exceedingly complex. If a ſound is too low for making an impreſſion on the papillæ in their natural ſtate of relaxation, we are apt to over-ſtretch the organ, which produces a painful or irkſome feeling. When we examine a mite, or any very minute object, by the naked eye, a pain is propagated over every part of that organ. Several cauſes may concur in producing this pain, ſuch as the dilating of the pupil, and the adjuſting the cryſtalline lens; but the chief cauſe muſt be aſcribed to the preternatural intumeſcence and extenſion of the papillæ of the retina, the ſubſtance of which is a mere congeries of nervous terminations. This circumſtance

cumſtance confirms a former remark, that the immediate organs of ſenſation were more copiouſly ſupplied with nervous papillæ than thoſe parts whoſe uſes require not ſuch exquiſite ſenſibility; for a diſtinction in this reſpect is obſervable even among the ſenſitive organs themſelves. They are furniſhed with nerves exactly proportioned to the ſubtility of the objects whoſe impreſſions they are fitted to receive. The eye poſſeſſes by far the greateſt number. The particles of light are ſo minute, that, had not this wiſe proviſion been obſerved in the conſtruction of the eye, it could never have been able to diſtinguiſh objects with ſuch accuracy as at preſent it is capable of performing. When an inſipid body, or a body which conveys but a very feeble ſenſation of taſte, is applied to the tongue, we are conſcious of an effort which that organ makes in order to diſcover the quality of the body thus applied. This effort is nothing but the ſtretching of the nervous papillæ, that they may enlarge the field of contact with the body under examination.

The pleaſure or pain produced by the ſenſe of touch depends chiefly on the friction, or number of impulſes, made upon the papillæ. Embrace any agreeable body with your hand, and allow it to remain perfectly at reſt, and you will find the pleaſure not half ſo exquiſite as when the hand is gently moved backward and forward upon the ſurface. Apply the hand to a piece of velvet, and it is merely agreeable: Rub the hand repeatedly on the ſurface of the cloth, and the pleaſant feeling will be augmented in proportion to the number of impulſes on the papillæ. When a man is pinched with hunger, the ſight or idea of palatable food raiſes the whole papillæ of his tongue and ſtomach. From this circumſtance he is highly regaled by eating. But, if he eats the ſame ſpecies of food when his ſtomach is leſs keen, the pleaſure in the one caſe is not to be compared with what is felt in the other. The cauſe is obvious: His deſire was not ſo urgent; the object, of courſe, was leſs alluring; and therefore he was more remiſs in erecting his papillæ, or in putting them in a tone ſuited to ſuch eminent gratification.

The ſame obſervations are applicable to diſagreeable or painful

painful objects of contact. If the hand is laid upon a gritty ſtone, or a piece of ruſty iron, the feeling is diſagreeable; but if it is frequently rubbed upon the ſurface of theſe bodies, the feeling becomes inſufferably irkſome.

It is by the ſenſe of touch that men, and other animals, are enabled to perceive and determine many qualities of external bodies. By this ſenſe we acquire the ideas of hardneſs and ſoftneſs, of roughneſs and ſmoothneſs, of heat and cold, of preſſure and weight, of figure, and of diſtance. The ſenſe of touch is more uniform, and liable to fewer deceptions, than thoſe of ſmelling, taſting, hearing, and ſeeing; becauſe, in examining the qualities of objects, the bodies themſelves muſt be brought into actual contact with the organ, without the intervention of any medium, the variations of which might miſlead the judgment.

OF SEEING.

Of all the ſenſes, that of ſeeing is unqueſtionably the nobleſt, the moſt refined, and the moſt extenſive. The ear informs us of the exiſtence of objects at comparatively ſmall diſtances; and its information is often imperfect and fallacious. But the organ of ſight, which is moſt admirably conſtructed, not only enables us to perceive thouſands of objects at one glance, together with their various figures, colours, and apparent poſitions, but, even when unarmed, to form ideas of the ſun and planets, and of many of the fixed ſtars; and thus connects us with bodies ſo remote, that imagination is loſt when it attempts to form a conception of their immenſe magnitude and diſtances. This natural field of viſion, however great, has been vaſtly extended by the invention of optical inſtruments. When aided by the teleſcope, the eye penetrates into regions of ſpace, and perceives ſtars innumerable, which, without the aſſiſtance of art, would to us have no exiſtence. Our ideas of the beauty, magnitude, and remoteneſs or vicinity of external objects, are chiefly derived

derived from this delicate and acute inſtrument of ſenſation.

Before proceeding to the peculiarities of viſion, and the general properties of light, we ſhall give a ſhort deſcription of the ſtructure of the eye.

The globe of the eye is compoſed of three humours, called *aqueous*, *cryſtalline*, and *vitreous* ; and of the *retina*, *ciliary ligament*, and *iris*. All theſe are contained within the *ſclerotica* and *cornea*, or capſule of the eye. The white part of the cornea is opaque ; but the *pupil*, or *ſight* of the eye, through which the rays of light paſs, is tranſparent. The *aqueous humour* is a *meniſcus*, or a convex exteriorly, and concave internally. The *cryſtalline humour* is doubly convex ; and its exterior convexity is embraced by the concave ſurface of the aqueous. The *vitreous humour* is likewiſe a meniſcus ; its concave ſurface embraces the interior convexity of the cryſtalline, and its convex ſurface is encompaſſed by the *retina*, which is a fine expanſion of the medullary fibres of the optic nerve ſpread upon the convex ſurface of the vitreous humour, and covering the bottom of the eye. The *ciliary ligament* is a ring of fibres, which incloſe the edges of the cryſtalline, and ſtretch in right lines towards its center. When theſe fibres contract, the diſtance between the retina and cryſtalline is lengthened ; and that diſtance is ſhortened when theſe fibres are in a relaxed ſtate. The *iris* is that coloured circle which ſurrounds the pupil.

By this curious apparatus all the phænomena of viſion are conveyed to the mind. But, before we enter upon the manner in which the different parts of the eye concur in tranſmitting the rays of light and the images of objects to the retina, it will be neceſſary to give ſome general ideas concerning the nature of light, which is the univerſal medium of viſion.

Light conſiſts of innumerable rays, which proceed in direct lines from every part of luminous bodies. The motion of light, though not inſtantaneous, is inconceivably ſwift. To give ſome comparative idea of its great velocity, it has been diſcovered by philoſophers, that rays of light coming from the ſun reach this earth in
ſeven

ſeven minutes. Now, the diſtance of the earth from the ſun is ſo immenſe, that, ſuppoſing a cannon ball to move at the rate of 500 feet in a ſecond, it could not come from the ſun to the earth in leſs than 25 years. At this rate, the velocity of light will be above 10 million of times greater than that of a cannon ball.

The rays of light, though they proceed in direct lines from luminous bodies, are refracted, or bent out of their courſe, in paſſing through different mediums, as the air, glaſs, and every tranſparent ſubſtances; but, when they fall upon opaque bodies, they are reflected. Rays proceeding from any object, and paſſing through a convex glaſs, or lens, are refracted and collected into a point, or ſmall ſpace, at a certain diſtance from the glaſs, which is called the *focus* of that lens.

The white light conveyed to us by the ſun is not homogeneous, but conſiſts of ſeven differently-coloured rays, or what are called the *primary colours*. Theſe differently-coloured rays were diſcovered by Sir Iſaac Newton to have different degrees of refrangibility. When the white light of the ſun was made to paſs through a glaſs priſm, he found, that, inſtead of retaining its original whiteneſs, it exhibited ſeven diſtinct colours, and that this phænomenon was produced by the ſeveral rays in the compoſition of white light being more or leſs refracted, or turned from their direct courſe. The ſimple primary colours are ſeven in number, namely, red, orange, yellow, green, blue, indigo, and violet. Red is the leaſt, and violet the moſt refrangible parts of white light. A proper mixture of all the ſeven primary colours conſtitutes whiteneſs; and by various combinations of the primary colours, all the compound colours exhibited either in Nature or art are produced. Any ſurface appears black when it reflects little or no light.

The different humours of the eye, and the cryſtalline lens, are all denſer than air or water; of courſe, their power of refracting the rays of light is likewiſe greater. The rays proceeding from every point of an object enter the pupil; and the refraction of the different parts of the eye, which act as a lens, neceſſarily makes them croſs

each

each other in their paſſage to the retina. After croſſing, they diverge till they are ſtopped by the retina, where they form an inverted picture. The upper part of the object is painted on the lower part of the retina, and the right ſide upon the left, &c. The celebrated Kepler firſt diſcovered, that diſtinct, but inverted, pictures of every object we behold are painted on the retina by the rays of light proceeding from viſible objects. This diſcovery naturally led Kepler, as well as many other philoſophers ſince his time, to inquire how we ſhould ſee objects erect from inverted images on the retina.

Many ingenious theories have been invented, and many volumes have been written, in order to explain this ſeemingly-difficult queſtion. To give even a curſory view of theſe theories would not only be tedious, but in a great meaſure uſeleſs. We ſhall, therefore, only remark, that their authors uniformly aſſumed it as a principle, that, becauſe the pictures are inverted on the retina, the mind ought alſo to perceive them in the ſame poſition. It is certain, that, unleſs diſtinct images are painted on the retina, objects cannot be clearly perceived. If, from too little light, remoteneſs, or any other cauſe, a picture is indiſtinctly painted on the retina, an obſcure or indiſtinct idea of the object is conveyed to the mind. The picture on the retina, therefore, is ſo far the cauſe of viſion, that, unleſs this picture be clear and well defined, our ideas of the figure, colour, and other qualities of any object preſented to the eye, will be obſcure and imperfect. The retina of the eye reſembles a canvas on which objects are painted. The colours of theſe pictures are bright or obſcure, in proportion to the diſtances of the objects repreſented. When objects are very remote, their pictures on the retina are ſo faint, that they are entirely obliterated by the vigorous and lively impreſſions of nearer objects, with which we are every way ſurrounded. On the other hand, when near objects emit a feeble light only, compared with that which proceeds from a remote object, as, for example, when we view luminous bodies in the night, then very diſtant objects make diſtinct pictures on the retina,

retina, and become perfectly viſible. Hence a man, by placing himſelf in a dark ſituation, and looking through a long tube, without the intervention of a glaſs, may make a kind of teleſcope, which will have a conſiderable effect even during the day. For the ſame reaſon, a man at the bottom of a deep pit can ſee the ſtars at noon.

The firſt and greateſt error in viſion, in the opinion of many authors, ariſes from the inverted repreſentation of objects upon the retina; and they maintain, that, till children learn the real poſition of bodies by the ſenſe of feeling, they ſee every object inverted. But new-born animals, whether of the human or brute ſpecies, ſee objects, not inverted, but in their real poſitions, independently of all experience, or of any opportunity of rectifying the ſuppoſed illuſion by the ſenſe of touch. Animals ſee objects in their real poſition by a law of Nature, and by the inſtrumentality of the eye and optic nerve. Were it not a law of Nature, or of the conſtitution of animals, to ſee objects erect, though their images be inverted on the retina, an inverted object could not poſſibly appear inverted; for, in this caſe, we ſhould not be obliged to have recourſe to experience, or to the ſenſe of feeling. Beſides, it is an eſtabliſhed fact, that blind men, who had been reſtored to ſight by chirurgical operations, inſtantly ſaw objects in their real poſition *. There is no relation to the principles of optics, in the ſenſation of feeling, by which an image, painted by rays of light on ſoft white nervous terminations, is converged through a moſt opaque body, in a long courſe of perfect darkneſs, to the brain. Indeed, the ſenſe by which the perceiving nerves of any kind are affected, is not an image or idea of the object. The idea of redneſs has nothing in common with the leaſt refrangible portions of light ſeparated from the other ſix coloured rays of which white light is compoſed. The pain of burning repreſents not to the mind any thing of that ſwift and ſubtle matter by which the nervous threads are broken or deſtroyed. There is nothing in the idea of a ſharp ſound,

 from

* Haller. Phyſiol. tom. 2. pag. 87. S.

from a cord of a certain length, which can inform the mind that this cord vibrates 2000 times in a second *.

Another question with regard to vision has been much agitated by philosophers. Because a separate image of every object is painted on the retina of each eye, it was concluded, that we naturally see all objects double; that we learn to correct this error of vision by the sense of touching; and that, if the sense of seeing were not constantly rectified by that of touching, we should be perpetually deceived as to the position, number, and situation of objects. The Count de Buffon mentions the real fact, though he ascribes it to a wrong cause. 'When two 'images,' says he, 'fall on *corresponding* parts of the 'retinæ, or those parts which are always affected at the 'same time, objects appear single, because we are *accus-'tomed* to judge of them in this manner. But, when the 'images of objects fall upon parts of the retinæ which 'are not usually affected at the same time, they then appear 'double, because we have not acquired the *habit* of rec-'tifying this unusual sensation. Mr. Cheffelden, in his 'anatomy, relates the case of a man who had been affected 'with a strabismus, or squinting, in consequence of a 'blow on the head. This man saw every object double 'for a long time: But he gradually learned to correct 'this error of vision, with regard to objects which were 'familiar to him; and, at last, he saw every object single 'as formerly, though the squinting was never removed. 'This is a proof still more direct, that we really see all 'objects double, and that it is by *habit* alone we learn to 'conceive them to be single†.'

In this, and other passages, the Count de Buffon has pointed out the genuine cause (or ultimate fact) why we see objects single with two eyes. He tells us, that, though a distinct image is painted on each retina, whenever these images are painted on corresponding points of the retinæ, an object is perceived to be single. It is equally true, that, when one eye is distorted by the finger, or any other cause,

* For a more ample discussion of this point, see Haller. Physiol. tom. [illegible]; — and Dr. Reid's Inquiry. [illegible]

† Buffon, vol. 3. p. [illegible] Transl. [illegible]

caufe, in fuch a manner that the images are painted on points of the retinæ which do not correfpond, the object is perceived to be double. Objects which are much nearer, or much more remote, than that to which both eyes are directed, appear double. If a candle is placed at the diftance of ten feet, and a man holds his finger at arm's-length between his eyes and the candle, when he looks at the candle, he fees his finger double, and, when he looks at his finger, he fees the candle double. 'In this 'phænomenon,' Dr. Reid properly remarks, 'it is evi-'dent to thofe who underftand optics, that the pictures 'of objects which are feen double, do not fall upon points 'of the retinæ which are fimilarly fituated, but that the 'pictures of objects feen fingle do fall upon points fimi-'larly fituated. Whence we infer, that as the points of 'the two retinæ, which are fimilarly fituated with regard 'to the centres, do correfpond, fo thofe which are diffi-'milarly fituated do not correfpond. It is to be obferved, 'that although, in fuch cafes as are mentioned in the laft 'phænomenon, we have been accuftomed from infancy 'to fee objects double which we know to be fingle; yet 'cuftom, and experience of the unity of the object, 'never take away this appearance of duplicity*.'

The fenfe of feeing, without the aid of experience, conveys no idea of diftance. If not affifted by the fenfe of touching, all objects would feem to be in contact with the eye itfelf. Objects appear larger or fmaller according as they approach or recede from the eye, or according to the angle they fubtend. A fly, when very near the eye, feems to be larger than a horfe or an ox at a diftance. Children can have no idea of the relative magnitude of objects, becaufe they have no notion of the different diftances at which they are feen. It is only after meafuring fpace by extending the hand, or by tranfporting their bodies from one place to another, that children acquire juft ideas concerning the real diftances and magnitudes of objects. Their ideas of magnitude refult entirely from the angle formed by the extreme rays reflected from the fuperior and inferior parts of the object: Hence every near

* Dr. Reid's Inquiry, &c. page 287. S.

near object muſt appear to be large, and every diſtant one ſmall. But after, by touch, having acquired ideas of diſtances, the judgment concerning magnitude begins to be rectified. If we judge ſolely by the eye, and have not acquired the habit of conſidering the ſame objects to be equally large, though ſeen at different diſtances, the neareſt of two men, though of equal ſize, would ſeem to be many times larger than the fartheſt. But we know that the laſt man is equally large with the firſt; and, therefore, we judge him to be of the ſame dimenſions. Any diſtance ceaſes to be familiar to us, when the interval is vertical, inſtead of being horizontal; becauſe all the experiments by which we uſually rectify the errors of viſion, with regard to diſtances, are made horizontally. We have not the habit of judging concerning the magnitude of objects which are much elevated above or ſunk below us. This is the reaſon that, when viewing men from the top of a tower, or when looking up to a globe or a cock on the top of a ſteeple, we think theſe objects much ſmaller than when ſeen at equal diſtances in a horizontal direction. During the night, on account of the darkneſs, we have no proper idea of diſtance, and, of courſe, judge of the magnitude of objects ſolely by the largeneſs of the angle or image formed in the eye, which neceſſarily produces a variety of deceptions. When travelling in the night, we are liable to miſtake a buſh that is near us for a tree at a diſtance, or a diſtant tree for a buſh which is at hand. When benighted in a part of the country with which we are unacquainted, and, of courſe, unable to judge of the diſtance and figure of objects, we are every moment liable to all the deceptions of viſion. This is the origin of that dread which ſome men feel in the dark, and of thoſe ghoſts and horrible figures which ſo many people poſitively aſſert they have ſeen in the night. Such figures are commonly ſaid to exiſt in imagination only; but they often have a real exiſtence in the eye; for, when we have no other mode of recogniſing unknown objects but by the angle they form in the eye, their magnitude is uniformly augmented in proportion to their vicinity. If an object, at the diſtance of twenty or thirty paces, appears

to be only a few feet high, its height, when viewed within two or three feet of the eye, will ſeem to be many fathoms. Objects, in this ſituation, muſt excite terror and aſtoniſhment in the ſpectator, till he approaches and recogniſes them by actual feeling; for the moment a man examines an object properly, the gigantic figure it aſſumed in the eye inſtantly vaniſhes, and its apparent magnitude is reduced to its real dimenſions. But if, inſtead of approaching an object of this kind, the ſpectator flies from it, he retains the idea which the image of it formed in his eye, and he may affirm with truth, that he beheld an object terrible in its aſpect, and enormous in its ſize. Hence the notion of ſpectres, and of horrible figures, is founded in nature, and depends not ſolely on imagination.

When we have no idea of the diſtance of objects by a previous knowledge of the ſpace between them and the eye, we try to judge of their magnitudes by recogniſing their figures. But, when their figures are not diſtinguiſhable, we perceive thoſe which are moſt brilliant in colour to be neareſt, and thoſe that are moſt obſcure to be at the greateſt diſtance. From this mode of judging many deceptions originate. When a number of objects are placed in a right line, as lamps in a long ſtreet, we cannot judge of their proximity or remoteneſs but by the different quantities of light they tranſmit to the eye. Of courſe, if the lamps neareſt the eye happen to be more obſcure than thoſe which are more remote, the firſt will appear to be laſt, and the laſt firſt.

Before I diſmiſs this ſubject, I feel an irreſiſtible deſire of giving a ſhort view of the Abbé de Condillac's *Traité des Senſations* * ; a moſt ingenious performance, which, I believe, is not very generally known in this country.

In an advertiſement prefixed to this Treatiſe, the ſagacious and learned Abbé deſires his readers to abſtract themſelves from all their preconceived opinions, and to imagine

* From the edition 1754, in two volumes 12mo. S.

imagine the ſituation and feelings of a ſtatue, limited, at firſt, to a ſingle ſenſe, and afterwards acquiring gradually the whole five.

1. *Senſe of Smelling alone.*

A MAN, or a ſtatue, who had no ſenſe but that of ſmelling, could have no other ideas than thoſe of odours. He would be the ſmell of a roſe, a violet, or a jeſſamine, according as the effluvia of theſe objects acted upon his ſingle organ of ſenſation. From agreeable or diſagreeable ſmells he would acquire ideas of pleaſure and pain. By means of agreeable and diſagreeable ſmells frequently repeated, theſe ſenſations would remain in his memory, and produce deſire and averſion. He can now compare the ſmell of a roſe with that of an hemlock. As ſoon as he compares, he judges of the relation between two ideas. In proportion as theſe compariſons or judgments are repeated, he acquires, by habit, a greater facility in making them. He can judge of different degrees of pleaſure and pain. Hence, when he feels uneaſy, he recals pleaſant ſenſations which are paſt, and wiſhes for their return. This is the origin of deſire and want. Memory is the recollection only of what is paſt; but, when the ideas of objects preſent themſelves in ſo lively a manner, that he believes they are actually preſent, this operation of the mind is called imagination. Being limited to the uſe of one ſenſe, he would learn to diſtinguiſh ſmells with greater accuracy than beings endowed with more ſources of information. Abſtraction is the ſeparation of two ideas which have a natural connection. By reflecting that the ideas of pain and pleaſure reſult from different modifications of his exiſtence, he contracts the habit of ſeparating them, and thus acquires abſtract notions. To our ſtatue, a violet is a particular idea only; conſequently, all his abſtractions are limited to different degrees of pleaſure and pain. The ſucceſſion of ſenſations will give him ſome faint ideas of number, of paſt, and of future time. Duration is an idea purely relative, and changes according to the rapidity or ſlowneſs of our perceptions. Our ſtatue

tue is incapable of diſtinguiſhing dreams, or a lively imagination, from real ſenſations. By the aid of memory he recogniſes his identity, and knows his preſent from his paſt condition. From theſe remarks it appears, that a man limited to one ſenſe is capable of acquiring the rudiments of every human faculty, and that theſe faculties are only extended by the addition of other ſenſes. Nearly the ſame acquiſitions would be made, if a man were limited to any of the other ſenſes.

2. *Of Hearing alone.*

THE pleaſures of the ear ariſe chiefly from the ſucceſſion of ſounds conformably to the rules of melody or of harmony. Hence our ſtatue's deſires would not be confined to a ſingle ſound; he would wiſh to become a complete air. Sounds produce greater emotions than odours. They excite joy or ſadneſs independently of acquired ideas. Noiſe alone, without muſical expreſſion, would be agreeable: And muſic would convey pleaſure proportioned to the exerciſe of the ear. Simple, and even coarſe ſongs, would at firſt be raviſhing. But, when gradually accuſtomed to muſic more compounded, the ear would diſcover new ſources of delight. The pleaſure of a ſucceſſion of muſical tones being ſuperior to that of a continued noiſe, he would not confound the one with the other.

3. *Smelling and Hearing united.*

As theſe ſenſes, taken ſeparately, give to our ſtatue no idea of external objects, neither can they by their union. He would never ſuſpect that he had two different organs of perception, nor, at firſt, diſtinguiſh two modes of exiſtence in himſelf. Sounds and odours would be confounded, and ſeem to be only one ſimple modification. He would learn, however, by experience, and the aid of memory, to diſtinguiſh two ſenſations; and then he would think that his exiſtence was double. His train of ideas is more varied and extenſive, becauſe he has two kinds

of modification: and, perhaps, noise would seem so different from harmonious sounds, that he might imagine he had three senses.

4. *Taste alone, and Taste united with Smelling and Hearing.*

When limited to taste alone, the statue would acquire the same mental powers as with smelling or hearing. Taste would contribute more to his happiness and misery than smelling or hearing; because savours, in general, affect us more than smells, or even harmonious sounds.

When taste is united with smelling and hearing, the statue, after learning to know them separately, would be enabled to distinguish these sensations, even when transmitted to him at the same time; and therefore his existence would in some measure be tripled. The union of these senses would still farther extend and diversify the train of his ideas, augment the number of his desires, and make him contract new habits.

5. *Of Sight alone.*

Sight and all sensations are internal, and belong to the mind. The difficulty is to conceive how we refer these sensations to external objects or causes. Our statue would consider light and colour as modes of his own existence; but could have no idea that they belonged to bodies distinct from himself. At first he would not be able to distinguish one colour from another; but he would soon acquire the habit of considering one colour at a time, and thus learn to distinguish them. By sight alone he could have no idea of figure, situation, extension, or motion.

6. *Sight united with Smell, Hearing, and Taste.*

This union would augment our statue's mode of existence, extend the chain of his ideas, and multiply the objects of his attention, of his desires, and of his enjoyments. But he would still continue to perceive himself alone,

alone, and could have no idea of external objects. He would see, smell, taste, and hear, without knowing that he had eyes, nose, mouth, or ears, nor even that he had a body. With the same colour before his eyes, if a succession of smells, savours, and sounds, were presented to him, he would consider himself as a colour successively odoriferous, savoury, and sonorous. If the same odour were constantly present with him, he would consider himself as a savoury, sonorous, and coloured odour.

7. *Of Touching alone.*

The smallest degree of sentiment, or feeling, which a man limited to the sense of touching could have, would arise from the action of different parts of the body, and particularly from the motion of respiration. This the Abbé calls the *fundamental sentiment*, because with it life commences. As soon as this fundamental sentiment has undergone any change, the statue is conscious of his own existence. When not struck by any external body, and placed in a temperate tranquil air, of an equal degree of heat, he would only recognise his existence by the confused impression resulting from the motion of respiration. He cannot distinguish the different parts of his body, and consequently has no idea of extension. Different feelings perceived at the same time convey a confused sensation only. But, when heat and cold are felt in succession, he distinguishes them, and retains in his memory the idea of each sensation. Touching different parts of his body, and of external objects, gradually unfolds the ideas of extension, solidity, softness, hardness, distance, &c. Hence he no longer confounds himself with his modifications. He is no longer heat or cold; but he perceives heat in one part and cold in another. By means of the hand, he distinguishes his own person from external objects. When he touches the parts of his body, each part returns a sensation. But, when he touches another body, he feels that it exists, but returns no sensation; and hence he learns that there are bodies which constitute no part of himself.

Children derive the greateſt happineſs from motion. Even falls do not deter them. A bandage on their eyes would give them leſs pain than a reſtraint on the uſe of their limbs. Motion, beſide many other advantages, gives them the moſt lively conſciouſneſs of their own exiſtence and powers. If exerciſe be pleaſant to children, it would be ſtill more ſo to our ſtatue; for as yet he not only knows no obſtacle to interrupt his movements, but he will ſoon experience all the pleaſures to be derived from motion. The ſtatue at firſt loves every body that does not hurt him. Poliſhed and ſmooth ſurfaces will be agreeable to him; and he will be delighted to find that he can at pleaſure enjoy warmth or coolneſs. He will receive peculiar pleaſure from objects, which, from their figure and magnitude, are moſt accommodated to the form of his hand. At other times, the difficulty of handling objects, on account of their ſize or weight, will give him pleaſure by ſurpriſe; and this pleaſure will be augmented by the ſpace he diſcovers around them, which will render the motion of his body from one place to another extremely agreeable. Solidity and fluidity, hardneſs and ſoftneſs, motion and reſt, will be pleaſant ſenſations; for the more he contraſts them, the more they will attract his attention and extend his ideas. But the habit he acquires of comparing and judging is the greateſt ſource of his pleaſures. He no longer touches objects ſolely for the pleaſure of handling them. He wiſhes to know their relations, and he feels as many agreeable ſenſations as he forms new ideas.

Touching expoſes him more frequently to pain than the other ſenſes. But pleaſure is always within his reach, and pain is felt only at intervals. His deſires conſiſt chiefly of the efforts of his mind to recal the moſt agreeable ideas. But that kind of deſire of which the ſenſe of touch renders him capable, includes motion, or the power of ſearching for ſenſations. Hence his enjoyments are not limited to the ideas preſented by the imagination, but extend to all the objects he can reach; and his deſires, inſtead of being concentrated into modes of his exiſtence, as in the other

other ſenſes, lead him always to external bodies, which are the objects of his love, hatred, and other paſſions.

By motion he acquires the idea of ſpace. Repeated experience of diſcovering new ſenſations renders him capable of curioſity. But pain repreſſes his deſire of moving, and makes him diffident. Hence he learns to move with caution; and the ſame chance that led him to lay hold of a ſtick, will teach him to uſe it for exploring what may be hurtful to him. Pleaſure and pain are the ſources of all his ideas, the number of which acquirable by our ſtatue is almoſt infinite. He learns to compare his different ſenſations, and to diſtinguiſh different bodies. He acquires the idea of figure, and becomes capable of reflection and abſtraction. He acquires likewiſe the ideas of number, of duration, of ſpace, and of immenſity.

8. *Of Touch united with Smelling.*

On this ſuppoſition, the ſtatue would perceive himſelf to be two different beings, one that he could touch, and another which he could not. When chance made him lay hold of an odorous body, he would find that its ſmell was ſtronger or weaker, in proportion as he brought the body nearer, or removed it farther from his face. This experiment frequently repeated will give him the idea that ſmell proceeds from, or is a quality of, bodies. By the ſame means he diſcovers the organ of ſmelling. From this ſource his ideas concerning the qualities of bodies are greatly extended.

9. *Hearing, Taſte, and Touching, united.*

At firſt our ſtatue is totally occupied with this new ſenſe, and believes himſelf to be the ſinging of birds, the noiſe of a caſcade, &c. By the exerciſe, however, of handling ſonorous bodies, or of letting them fall, he perceives that ſound is produced by impulſe or colliſion, gradually diſcovers this new organ, and that noiſe is a property of bodies even at a diſtance.

10. *Of Sight united with all the other Senses.*

The eye conveys no idea of diſtance, of magnitude, of figure, or of ſituation, without the aſſiſtance of touching. Either from chance, or from the pain occaſioned by too ſtrong a light, the ſtatue carries his hand to his eyes. The colours of objects inſtantly diſappear. He removes his hand, and the colours return. Hence he learns that colours are not modes of his exiſtence, but that they ſeem to be ſomething exiſting in his eyes, in the ſame manner as he feels at the ends of his fingers the objects he touches.

The Abbé, in the ſame ingenious manner, ſhows how, by experience and habit, by motion and touching, we acquire a facility in correcting the errors of viſion. But our limits permit us not to follow him any farther.

CHAPTER VII.

Of Infancy.

BY the term *Infancy*, in this chapter, is generally meant that portion of life which commences at birth, and terminates at that period when animals have acquired the power of ſelf-preſervation, without any aſſiſtance from their parents. This period varies greatly in different animals. Of courſe, when different ſpecies are mentioned, the term *infancy* muſt have very different limitations with regard to time.

The ſtate of infancy, in the human ſpecies, continues longer than in any other animal. Infants, immediately after birth, are indeed extremely helpleſs, and require every aſſiſtance and attention from the mother. Moſt writers, however, on this ſubject ſeem to have exaggerat-

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ed not only the imbecility, but the miseries, of the infant ſtate. ‘ An infant,’ ſays Buffon, ‘ is *more helpleſs* than ‘ the young of any other animal: Its uncertain life ſeems ‘ every moment to vibrate on the borders of death. It ‘ can neither move nor ſupport its body: It has hardly ‘ force enough to exiſt, and to announce, by groans, the ‘ pain which it ſuffers; as if Nature intended to appriſe ‘ the little innocent, that it is born to *miſery*, and that it ‘ is to be ranked among human creatures only to partake ‘ of their infirmities and of their afflictions *.’

This humiliating picture is partly juſt, and partly miſrepreſented. Though infants remain longer in a ſtate of imbecility than the young of other animals, they are by no means *more helpleſs*. The inſtant after birth, they are capable of ſucking whatever is preſented to their mouths. When in the ſame condition, the young of the opoſſum, of hares, rabbits, rats, mice, &c. can do no more. They can neither move nor ſupport their bodies. Beſides, many quadrupeds are deſtitute of the ſenſe of ſeeing for ſeveral days after birth. But, the faculty of viſion is enjoyed by infants the moment after they come into the world. This faculty, in a few hours, becomes a great ſource of pleaſure and amuſement to them; but it is denied, for ſome days, to many other ſpecies of animals. The young of moſt birds are equally weak and helpleſs as human infants. The former have no other powers but thoſe of reſpiration, opening their mouths to receive food from the parent, and ejecting the excrement, after the food has been properly digeſted. If infants really ſuffer more pain and miſery than other animals in the ſame ſtate, Nature ſeems not to merit that ſeverity of cenſure which ſhe has ſometimes received. Men in ſociety, like domeſtic animals, by luxury, by artificial modes of living, by unnatural and vicious habits, debilitate their bodies, and tranſmit to their progeny the ſeeds of weakneſs and diſeaſe, the effects of which are not felt by thoſe who live more agreeably to the general œconomy and intentions of Nature. The children of ſavages, for the ſame reaſon, whether in the hunting or ſhepherd ſtate, are more robuſt, more

* Buffon, vol. 2. pag. 369. Tranſlat. S.

more healthy, and liable to fewer diseases, than those produced by men in the more enlightened and refined stages of society. Even under the same governments, and in the same state of civilization, a similar gradation of imbecility and disease is to be observed. The children of men of rank and fortune are, in general, more puny, debilitated, and diseased, than those of the peasant or artificer. Still, however, children, in their progress from birth to maturity, have innumerable sources of pleasure, which alleviate, if they do not fully compensate, the pain which must unavoidably be endured, whether in a more natural or more artificial state of mankind. If luxury and civilization debilitate the constitutions of children, they give rise to many real enjoyments which are totally unknown to the savage. His wants are fewer; but, his gratifications are more than proportionally diminished.

Though the period of human infancy be proportionally long, it is too often increased by improper management. In this, and many other countries of Europe, infants have no sooner escaped from the womb of their mother, and have enjoyed the liberty of stretching their limbs, than they are condemned to a more cruel and unnatural bondage. The head is fixed in one position; the legs are fettered; the arms are bound down to the sides; and the little innocents are laced with bandages so strait that they cannot move a single joint. The restraint of swaddling bands must be productive of pain. Their original intention was to prevent the head and limbs from being distorted by unnatural or hurtful positions. But it was not considered, that the efforts made by infants to disentangle themselves, have a greater tendency to distort their members than any postures they could assume, if they enjoyed a greater degree of liberty. But, if the efforts for liberty made by infants fettered in this cruel manner be hurtful, the state of inactivity in which they are forced to remain, is, perhaps, equally noxious. Infants, as well as all young animals, are extremely prone to motion. It promotes the growth and expansion of their organs. It likewise invigorates all their members, and facilitates the circulation and secretion of their different fluids. But, when infants

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are deprived of exercife, or of the power of performing their natural movements, the oppofite effects are produced. The want of exercife retards their growth and weakens their conftitution. Thofe children, therefore, who are allowed full freedom of motion, will always be the the moft healthy and the moft vigorous. We are, however, happy to remark, that, by the efforts of philofophers and phyficians, the practice of employing tight bandages has of late become lefs general, efpecially among intelligent midwives and mothers. But, to eradicate long eftablifhed prejudices, and to diffufe more enlightened and falutary notions through a whole country, cannot be effected without a great length of time and vigorous exertions.

From what caufes or circumftances particular modes in the management of infants originate, it is difficult to determine. But, it is certain that favages, and the ruder nations, in their treatment of infants, often difcover more difcernment, and propriety of conduct, than are to be found in the moft polifhed ftages of fociety. The negroes, the favages of Canada, of Virginia, of Brafil, and the natives of almoft the whole of South-America, inftead of ufing fwaddling-bands, lay their infants naked into hammocks, or hanging beds of cotton, or into cradles lined with fur. The Peruvians leave the arms of their infants perfectly loofe in a kind of fwathing-bag. When a little older, they are put, up to the middle, in a hole dug out of the earth, and lined with linen or cotton. By this contrivance, their arms and head are perfectly free, and they can bend their bodies, and move their arms and head, without the fmalleft danger of falling, or of receiving any injury. To entice them to walk, whenever they are able to ftep, the breaft is prefented to them at a little diftance. The children of negroes, when very young, cling round, with their knees and legs, one of their mother's haunches, and grafp the breaft with their hands. In this pofition they adhere fo firmly, that they fupport themfelves without any affiftance, and continue to fuck without danger of falling, though the mother moves forward, or works at her ufual labour. Thefe

children,

children, at the end of the ſecond month, begin to creep on their hands and knees; and, in this ſituation, they acquire, by habit, the faculty of running with ſurpriſing quickneſs.

Savages are remarkably attentive to the cleanlineſs of their children. Though they cannot afford to change their furs ſo frequently as we do our linen, this defect they ſupply by other ſubſtances of no value. The ſavages of North-America put wood-duſt, obtained from decayed trees, into the bottom of the cradle, and renew it as often as it is neceſſary. Upon this powder the children are laid, and covered with ſkins. This powder is very ſoft, and quickly abſorbs moiſture of every kind. The children in Virginia are placed naked upon a board covered with cotton, and furniſhed with a proper hole for tranſmitting the excrement. This practice is, likewiſe, almoſt general in the eaſtern parts of Europe, and particularly in Turkey. It has another advantage: It prevents the diſmal effects which too often proceed from the negligence of nurſes.

Many northern nations plunge their infants, immediately after birth, into cold water, without receiving any injury. The Laplanders expoſe their new-born infants on the ſnow till they are almoſt dead with cold, and then throw them into a warm bath. During the firſt year, this ſeemingly harſh treatment is repeated three times every day. After that period, the children are bathed in cold water thrice every week. It is a general opinion in northern regions, that cold bathing renders men more healthy and robuſt; and, hence, they inure their children, from their very birth, to this habit. In the iſthmus of America, the inhabitants, even when covered with ſweat, plunge themſelves with impunity into cold water. The mothers bathe in cold water, along with their infants, the moment after delivery; yet, much fewer of them die of child-bearing, than in nations where a practice of this kind would be conſidered as extremely hazardous.

With regard to the food of infants, it ſhould conſiſt, for the firſt two months, of the mother's milk alone. A child

child may be injured by allowing it any other nouriſh-ment before the end of the firſt month. In Holland, in Italy, in Turkey, and over the whole Levant, children, during the firſt year, are not permitted to taſte any other food. The Canadian ſavages nurſe their children four or five years, and ſometimes ſix or ſeven. In caſes of neceſſity, the milk of quadrupeds may ſupply that of the mother. But, in ſuch caſes, the child ſhould be obliged to ſuck the animal's teat; for the degree of heat is always uniform and proper, and the milk, by the action of the muſcles, is mixed with the ſaliva, which is a great promoter of digeſtion. Several robuſt peaſants have been known to have had no other nurſes than ewes. After two or three months, children may be gradually accuſtomed to food ſomewhat more ſolid than milk. Before the teeth ſhoot through the gums, infants are incapable of maſtication. During that period, therefore, it is obvious that Nature intended they ſhould be nouriſhed ſolely by ſoft ſubſtances. But, after they are furniſhed with teeth, it is equally obvious, that they ſhould occaſionally be allowed food of a more ſolid texture.

The bodies of infants, though extremely delicate, are leſs affected by cold than at any other period of life. This effect may be produced by the ſuperior quickneſs in the pulſation of the heart and arteries which takes place in ſmall animals. The pulſe of an infant is more frequent than that of an adult. The pulſe of a horſe, or of an ox, is much ſlower than that of a man; and the motion of the heart, in very ſmall animals, as that of a linnet, is ſo rapid that it is impoſſible to count the ſtrokes.

The lives of children, during the firſt three or four years, are extremely precarious. After that period, their exiſtence becomes gradually more certain. According to Simpſon's tables of the degrees of mortality at different ages, it appears, that, of a certain number of infants brought forth at the ſame time, more than a fourth part of them died the firſt year, more than a third in two years, and at leaſt one half at the end of the third year. Mr. Simpſon made this experiment upon children born in London. But, the mortality of children is not nearly ſo

great in every place; for M. Dupré de S. Maur, by a number of experiments made in France, has ſhown, that one half of the children born at the ſame time are not extinct in leſs than ſeven or eight years.

To treat of the diſeaſes of children, or to enter minutely into the cauſes which contribute to the great mortality of mankind in early infancy, is no part of our plan. In general, theſe cauſes are to be referred to unnatural practices in the management of children, introduced by ſuperſtition, by ignorance, and by fooliſh notions ariſing from over-refinement, from prejudice, and from hypothetical ſyſtems, while the œconomy and analogy of Nature, in the conduct and ſituation of the inferior animals, are almoſt totally neglected. Every animal, except the human ſpecies, brings forth its young without any foreign aid. But, incredible numbers of children, as well as of mothers, are daily maimed, enfeebled, and deſtroyed, by the ignorance and barbarity of midwives and accoucheurs. An infant is no ſooner brought into the world than it is crammed with phyſic. Nature's medicine for cleanſing the bowels of infants is the milk of the mother. But, midwives abſurdly imagine that drugs will anſwer this purpoſe much better. All other animals that give ſuck nurſe their own offspring: But, we too frequently delegate this tender and endearing office to ſtrange women, whoſe conſtitutions, habits of life, and mental diſpoſitions, are often totally different from thoſe of the genuine parent. Infants, recently after birth, frequently ſuffer from giving them, inſtead of the mother's milk, wine-whey, water-gruel, and ſimilar unnatural kinds of nouriſhment. In this period of their exiſtence, however, very little food, but a great deal of reſt, is neceſſary for promoting their health, and ſecuring their eaſe and tranquillity; for infants, when not teazed by officious cares, ſleep almoſt continually during ſeveral weeks after birth. Young animals are naturally fond of being in the open air; but, our infants, particularly in large towns, are almoſt perpetually ſhut up in warm apartments, which both relaxes their bodies and enervates their minds. The great agility, ſtrength, and fine proportions of ſavages, are reſults of a hardy

hardy education, of living much in the open air, and of an unreftrained ufe of all their organs the moment after they come into the world.

In young animals, as well as in infants, there is a gradual progrefs, both in bodily and mental powers, from birth to maturity. Thefe powers are unfolded fooner or later, according to the nature and exigencies of particular fpecies. This progrefs, in man, is very flow. Man acquires not his full ftature and ftrength of body till feveral years after the age of puberty: And, with regard to his mind, his judgment and other faculties cannot be faid to be perfectly ripe before his thirtieth year.

In early infancy, though the impreffions received from new objects muft be ftrong, the memory appears to be weak. Many caufes may concur in producing this effect. In this period of our exiftence, almoft every object is new, and, of courfe, engroffes the whole attention. Hence the idea of any particular object is obliterated by the quick fucceffion and novelty of others, joined to the force with which they act upon the mind. Haller afcribes this want of recollection to a weaknefs of memory; but, it feems rather to proceed from a confufion which neceffarily refults from the number and ftrong impreffions of new objects. The memory ripens not fo much by a gradual increafe in the ftrength of that faculty, as by a diminution in the number and novelty of the objects which folicit attention. In a few years children are enabled to exprefs all their wants and defires. The number of new objects daily diminifhes, and the impreffions made by thofe with which they are familiar become comparatively fmall and uninterefting. Hence their habits of attention, and the ardour of their minds, begin to relax. Inftead of a general and undiftinguifhing gratification of their fenfes, this is the period when it is neceffary to ftimulate children, by various artifices, to apply their minds fteadily to the examination of particular objects, and to the acquifition of new ideas from more complicated and refined fources of information. The great bafis of education is a habit of attention. When this important point is gained, the minds of children may be molded into any form. But

that restlessness, and appetite for motion, which Nature, for the wisest purposes, has implanted in the constitution of all young animals, should not be too severely checked. Health and vigour of body are the surest foundations of strength and improvement of mind.

With regard to the duration of infancy, from man to the insect tribes, it seems, in general, to be proportioned, not to the extent of life, but to the sagacity or mental powers of the different classes of animated beings. The elephant requires 30 years, and the rhinoceros 20, before they come to perfect maturity, and are enabled to multiply their species. But these years mark not the period of infancy; for the animals, in a much shorter time, are capable of procuring their own food, and are totally independent of any aid from their parents. The same remark is applicable to the camel, the horse, the larger apes, &c. Their ages of puberty are four, two and a half, and three years. But, in these quadrupeds, the terminations of infancy are much more early. The smaller quadrupeds, as hares, cats, mice, &c. are mature at the end of the first year after birth; and the Guiney-pig and rabbit require only five or six months. There is a gradation of mental powers, though not without exceptions, from the larger to the more minute quadrupeds; for the dog and fox, whose sagacity is very great, come to maturity in one year, and their state of infancy is short. But, of all animals, the infancy and helpless condition of man are the most prolonged; and the superiority and ductility of his mind will not be questioned.

The infant state of birds is very short. Most of the feathered tribes arrive at perfection in less than six months; and their sagacity is comparatively limited.

With regard to fishes, if the whale and seal kind, who suckle their young, be excepted, they receive no aid from their parents. Fishes no sooner escape from the eggs of their mother, than they are in a condition to procure nourishment, and to provide, in some measure, for their own safety. Of the sagacity of fishes, owing to the element in which they live, we have very little knowledge. But, their general character is stupidity, joined to a vora-

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cious and indiſcriminating appetite for food. In oppoſition to an almoſt general law of Nature which ſubſiſts among other animals, fiſhes devour, without diſtinction, every ſmaller or weaker animal, whether it belongs to a different ſpecies, or to their own. In animals of a much higher order, voracity of appetite is ſeldom accompanied with ingenuity or elegance of taſte. When the principal attention of an animal is engroſſed with any ſenſual appetite, it is a fair concluſion that the mental powers are weak, becauſe they are chiefly employed upon the groſſeſt of all objects. If this obſervation be juſt, fiſhes muſt be ranked among the moſt ſtupid animals of equal magnitude and activity.

The infant ſtate of inſects is a various and complicated ſubject. After they eſcape from the egg, they undergo ſo many changes, and aſſume ſuch a variety of forms, that it is difficult to determine the period of their exiſtence which correſponds to the condition of infancy in the larger animals. Different ſpecies remain longer or ſhorter in the form of worms, caterpillars, or grubs, before they are changed into chryſalids, and afterwards into flies. When young, like other animals, they are ſmall and feeble: But, even in their moſt helpleſs condition, with a very few exceptions, Nature is their only nurſe. They require no aid from their parents, who, in general, are totally unacquainted with their progeny. But, as formerly obſerved, when treating of inſtinct, the mothers uniformly depoſit their eggs in ſituations which afford both protection and nouriſhment to their young. The parent fly, according to the ſpecies, invariably, unleſs reſtrained by neceſſity, depoſits her eggs upon particular plants, in the bodies of other animals, in the earth, or in water. Whenever, therefore, an inſect receives exiſtence in its primary form, all its wants are ſupplied. Though the mother, after the worms iſſue from the eggs, takes no charge of her offspring, and frequently does not exiſt at the time they come forth, yet, by an unerring and pure inſtinct, ſhe uniformly places them in ſituations where the young find proper nouriſhment, and every thing neceſſary to their feeble condition.

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To this general law, by which inſects are governed, there are ſeveral exceptions. Bees, and ſome other flies, not only conſtruct neſts for their young, but actually feed, and moſt anxiouſly protect them.

From what has been ſaid concerning the infancy of animals, one general remark merits attention. Nature has uniformly, though by various modes, provided for the nouriſhment and preſervation of all animated beings while they are in an infantine ſtate. Though the human ſpecies continues long in that ſtate, the attachment and ſolicitude of both parents, inſtead of abating, in proportion to the time and labour beſtowed on their progeny, conſtantly augment, and commonly remain during life. The reciprocal affection of parents and children is one of the greateſt ſources of human happineſs. If the love of children were not ſtrong, and if it did not increaſe with time, the labour, the conſtant attention, the anxiety and fatigue of mothers would be inſufferable. But here Nature, whoſe wiſdom is always conſpicuous, makes affection brave every difficulty, and ſooth every pain. If a child be ſickly, and require uncommon care, the exertions of the mother are wonderfully ſupported: Pity unites with love; and theſe two paſſions become ſo ſtrong, that hardſhips, and fatigue of every kind, are ſuffered with chearfulneſs and alacrity.

With regard to the inferior tribes of animals, Nature has not been leſs provident. To quadrupeds and birds ſhe has given a ſtrong and marked affection for their offſpring, as long as parental care is neceſſary. But, whenever the young begin to be in a condition to protect and provide for themſelves, the attachment of the parents gradually ſubſides; they become regardleſs of their offſpring, at laſt baniſh them, with blows, from their preſence, and, after that period, ſeem to have no knowledge of the objects which ſo lately had engroſſed all the attention of their minds, and occupied all the induſtry and labour of their bodies.—Here the dignity and ſuperiority of man appears in a conſpicuous light. Inſtead of loſing the knowledge of his offspring after they arrive at maturity,

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his affection expands, and embraces grandchildren, and great-grandchildren, with equal warmth as if they had immediately originated from himself.

CHAPTER VIII.

Of the Growth, and Food, of Animals.

IT is a law of Nature, that all organized bodies, whether animal or vegetable, require food, in order to expand and strengthen their parts when young, and to preserve health and vigour after they have arrived at maturity. The food of animals is digested in the stomach and intestines: By this process it is converted into chyle, and absorbed by the lacteal vessels, in the manner described in Chap. II. pag. 50. But how this chyle, or nutritious matter, after mingling with the general mass of blood, contributes to the growth, and repairs the waste of animal bodies, is a mystery which probably never will be unfolded by human sagacity. It has, however, like many other secrets of Nature, given rise to several ingenious theories and conjectures, some of which shall be slightly mentioned.

Buffon considers the bodies of animals and vegetables as what he calls *internal moulds*. He says, that the matter of nutrition is not applied by juxta-position, but that it penetrates the whole mass; that each part receives and applies those particles only which are peculiar and necessary to its own nature; and that, by this means, the whole parts of the body are gradually and proportionally augmented. This nutritive matter, he remarks, is organic, and similar to the body itself; and hence the size of the body is increased, without any change in its figure or substance. The matter ejected by the different excretions he considers to be a separation of the dead from the vivifying and organic parts of nourishment, which are distri-

buted over the body by an active power: This power, ſimilar to that of gravity, penetrates the internal ſubſtance of the body, and attracts the organic particles, which are thus puſhed on through all its parts. As theſe organic paritcles are ſimilar to the body itſelf, their union with the different parts augments its ſize, without changing its figure. To unfold an embryo or germ, nothing more is requiſite than that it contain, in miniature, a body ſimilar to the ſpecies, and be placed in proper circumſtances for the acquiſition of freſh organic particles to increaſe its ſize and unfold its members. Hence nutrition, developement, and reproduction, are all effects of the ſame cauſe.

This account of the nutrition and growth of organic bodies has the appearance of an ingenious theory. But an attentive reader will eaſily perceive, that it contains no other information, than that animals and vegetables are nouriſhed and grow by the intervention of the nutritious particles of food. This is a fact univerſally known and admitted. But, we are ſtill as ignorant as ever of the mode by which this myſterious operation is performed.

Other authors have ſuppoſed that the brain is a large gland; that the nerves diſtributed over the whole body are the ducts or canals of this gland; and that the principal uſe of the brain is to ſecrete nutritious matter, and to tranſmit it by the nerves to the various parts of the ſyſtem, in order to expand the different organs of which it is compoſed, or to repair the waſte they may have ſuffered from labour and other cauſes.

This theory preſuppoſes that the nerves are tubular, and contain a fluid: But both of theſe circumſtances have hitherto eluded the reſearch of the ableſt anatomiſts. Beſides, the learned and indefatigable Doctor Monro, in his *Nervous Syſtem*, has rendered it highly improbable that the nerves are the inſtruments of nutrition. The Doctor reaſons in the following manner.—On comparing different animals, he remarks, we find no correſpondence between the ſize of their brain, the rapidity of their growth, or the quantity of nouriſhment they receive. An ox is ſix times heavier than a man; but the brain of an ox weighs not above a fourth part of that of a man. On this ſuppoſi-

ſuppoſition, an ox's brain muſt ſecrete twenty-four times more nouriſhment than a portion equal to it of the human brain. In two years an ox acquires his full ſize. His brain muſt, of courſe, be ſuppoſed to tranſmit daily through the nerves two or three pounds of fleſh, bones, &c. But the much larger brain of a man does not, in an equal time, add to his body a fiftieth part of that weight.

'In monſters,' ſays the Doctor, 'I have found the 'limbs very plump, though the brain was very ſmall. 'Nay, in ſome monſters, the head has been wanting, 'yet the limbs were as large and perfect as common. In 'other monſters, with one head and two bodies, I have 'found that the brain furniſhed the nerves of the head 'and ſpinal marrow on the right ſide of the monſter; 'yet the left ſpinal marrow, at the top of which there 'was only a ſmall medullary knob, about the ſize of a 'large pea, was as perfect as the right one; and that 'body, and its limbs, were as large, and as well nouriſhed, 'as thoſe on the right ſide. On the other hand, where 'there were two heads of the ordinary ſize, and only one 'body, the limbs were not remarkable for their ſize.

'We ſee that organs, of which the nerves are ſo ſmall 'that we cannot trace them by diſſection, as the bones, 'the placenta, &c. grow as quickly as the other organs, 'in which the nerves are large and numerous.

'A year after I had cut acroſs the ſciatic nerve of a 'living frog, I could not perceive that limb ſmaller than 'the other; yet it continued to be inſenſible and moti-'onleſs. Nay, when I had broken the bones of the in-'ſenſible limb, or wounded the ſkin and fleſh, I found 'that the callus formed, and the wounds healed, as rea-'dily as if the nerve had been entire. The event was 'the ſame after dividing, tranſverſely, the lower or poſte-'rior end of the ſpinal marrow of the frog.

'It is well known,' concludes our author, 'that, if 'powder of madder root is mixed with the food of a 'young animal, the bones become red; or, if a bone 'has been broken, that the callus joining its parts will 'be red. The ſerum of the blood, in the firſt place, is

 'deeply

'deeply tinged; but the red colour of the bones is not 'solely, nor even chiefly, owing to the coloured serum 'or blood circulating; for I have found, that, after in-'jecting water into the vessels till these were emptied of 'the blood, and that the water came out colourless, the 'tinge in the bones appeared equally deep, and was, 'therefore, plainly owing to a great quantity of the red 'earth added to the bones in the time of their growth. 'But this earth was not transmitted by the nerves; for 'the colour of these, as I found, remained unchanged.'

That the nutritious particles of food are conveyed by the arteries, and applied by their extremities to the various parts of animal bodies which require to be repaired or expanded, is an opinion not only best supported by facts, but adopted by all the more rational physiologists. The principal facts and arguments in support of this theory shall now be mentioned.

The chyle, as formerly remarked, is converted into blood. The glutinous part of the blood, known by the name of *coagulable lymph*, resembles the white of an egg. That the white of an egg is the sole nourishment of the chick before its exclusion, is an established fact; and the conclusion, from analogy, that the lymph of blood is destined for the growth and reparation of animal bodies, is by no means unnatural. 'Without repeating,' says Dr. Monro, 'our extreme uncertainty as to the tubu-'lar nature of the nerves, and the improbability that 'canals so exceedingly minute as those within the nerves 'must be, and of such length, are destined for the con-'veyance of glue, do we not find, that this very matter 'is separated by the exhalant branches of the arteries of 'the peritoneum, pleuræ, and other shut sacs, and, uni-'versally, by the branches of the arteries of the cellular 'membrane?—The kinds of matter necessary for the 'growth and nourishment of our several organs are so 'various and different in their nature, that it is altogether 'incredible they can be furnished by the nerves: Thus, 'water is needed for the extension of the fore-part of 'the eye, viscid matter for the crystalline and vitreous 'humours, earth for the growth of the bones, &c.;

'whereas

'whereas we can as eafily conceive thefe to be furnifhed 'by the arteries, as that, in one place, they fhould furnifh 'faliva, in another bile, &c.—As the wafte of the feveral 'organs is carried off by the veffels, either circulating 'or abforbent, why fhould we doubt that the circulating 'fluids can add a particle in the place of one that has 'been carried off, or that an artery can fupply what has 'been abforbed by a lymphatic vein? As it is granted 'that the fecretion of all other kinds of matter in the 'bodies of animals is performed by the branches of the 'arteries, is it not incredible that there fhould be an ex-'ception to the general rule in the fecretion of the nou-'rifhment? Surely that power which can convert the 'food into blood, and can change the blood into bile and 'faliva, is fufficient to convert it into nourifhment.

'I will now add,' continues our author, 'that in calli, 'cicatrices, or accretions, there are numberlefs new formed 'veffels filled, in the living animal, with red blood, and 'which can readily be injected. Nay, I found by experi-'ment, that fuch new formed veffels, produced by the 'oppofite fides of a wound, unite into continued canals, 'or anaftomofe.—If, then, in a callus, new earthy or 'offeous fibres, and new veficls, can be formed by the 'original arteries, muft we not believe that the wafte of 'this earth, and of thefe veffels, can be ever after fup-'plied by the arteries which formed them? If fo, are we 'not to conclude, that the wafte of other arteries, and of 'other organs, is fupplied in the fame manner from the 'arteries? If the quantity of blood naturally circulating 'through a limb be diminifhed, as by tying the trunk of 'the brachial artery, in the operation for an aneurifm, the 'arm lofes part of its ftrength and fize; but the lofs is lefs 'than, at firft fight, might be expected; becaufe the ana-'ftomofing (or uniting) canals foon come to be greatly 'enlarged.

'Upon the whole,' the Doctor concludes, 'there are 'few points in phyfiology fo clear, as, 1. That the arte-'ries prepare, and directly fecrete the nourifhment in all 'our organs; and, 2. That the nerves do not contain nor

'conduct

'conduct the nouriſhment, but, by enabling the arteries 'to act properly, contribute indirectly to nutrition.'

The ingenious Charles Bonnet endeavours to ſhow, that the parts of all organized bodies are contained, in miniature, in germs, or buds; that theſe germs, when placed in proper ſituations, gradually unfold and increaſe in magnitude; that the various members of animals and vegetables are expanded, both longitudinally and laterally, by food adapted to their reſpective natures; and that every germ actually includes the rudiments of the whole animals or vegetables which are to proceed from it during all ſucceſſive generations.

With regard to vegetables, it is true, that the ſeed firſt produces a ſmall tree, which it contained in miniature within its lobes. At the top of this ſmall tree a bud or germ is formed, which contains the ſhoot or tree that is to ſpring next ſeaſon. In the ſame manner, the ſmall tree of the ſecond year produces a bud which includes a tree for the third year; and this proceſs uniformly goes on as long as the tree continues to vegetate. At the extremity of each branch, buds are likewiſe formed, which contain, in miniature, trees ſimilar to that of the firſt year. From theſe, and ſimilar facts, it is concluded, that all theſe germs were contained in the original ſeed; for the firſt bud was ſucceeded by a ſimilar bud, which was not unfolded till the ſecond year, and the third bud was not expanded till the third year; and, of courſe, the ſeed may be ſaid to have contained not only the whole buds which would be formed in a hundred years, but all the ſeeds, and all the individuals, which would ſucceſſively arrive till the final deſtruction of the ſpecies.

Theſe facts are known and eſtabliſhed; but the reaſoning deduced from them is fallacious, or, what amounts to the ſame thing, is perfectly incomprehenſible. The ſeed is unqueſtionably the origin or cauſe of all future individuals, which may be infinite. But the idea that it really contained the germs of all the individuals which were to ſpring from it as a ſource, is not only abſurd, but exceeds all the powers of human imagination to conceive. Theories of this kind, of which there are too

many

many in almoſt every department of ſcience, hardly merit examination. Every ſeed, and every animal, according to this doctrine, includes in its own body an infinite poſterity ! If we aſſent to reaſonings of this kind, we muſt loſe ourſelves in the labyrinths of infinity ; and, inſtead of throwing light upon the ſubject, we ſhall involve it in tenfold darkneſs. All we know concerning the nature of growth and nutrition is extremely limited. We know that, in the animal kingdom, nutrition is performed by means of the blood, which is forcibly propelled through every part of the body by the action of the heart and arteries ; and that vegetables, in a ſimilar manner, are nouriſhed by the aſcenſion and diſtribution of the ſap. But, how the nutritive particles are applied to the various parts of organized bodies, and how they expand the organs, or repair their continual waſte and loſs of ſubſtance, we muſt content ourſelves with remaining in perpetual ignorance.

In general, the food of animals, and particularly of the human ſpecies, conſiſts of animal and vegetable ſubſtances, combined with water, or other fluids. The Gentoo, and ſome other ſouthern nations, live entirely upon vegetable diet. From the accounts we have of the different regions of the earth, it appears, that the natives of warm climates, where the cultivation of plants is practiſed, employ a greater proportion of vegetable food than in the more northern countries. The inhabitants of Lapland have little or no dependence on the fruits of the earth. They neither ſow nor reap. They ſtill remain, and, from the nature of their climate, muſt forever remain, in the ſhepherd ſtate. Their comparative riches conſiſt entirely of the number of rein-deer poſſeſſed by individuals. Their principal nouriſhment is derived from the fleſh and milk of theſe animals. In autumn, however, they catch great multitudes of fowls, moſt of them of the game kind. With theſe, while freſh, they not only ſupply their preſent wants, but dry and preſerve them through the winter. They likewiſe kill hares, and other animals, which abound in the woods and mountains ; but the fleſh of the bear is their greateſt delicacy. In their lakes and rivers, they have

have inexhauſtible ſtores of fiſhes, which, in ſummer and autumn, they dry in the ſun, or in ſtoves, and in winter they are preſerved by the froſt. The Laplanders drink water, or animal oils; but never taſte bread or ſalt. They live in a pure air, and have ſufficient exerciſe. Their conſtitutions are attempered to the coldneſs of the climate; and they are remarkable for vigour and longevity. The gout, the ſtone, the rheumatiſm, and many other diſeaſes which torture the luxurious in milder climes, are totally unknown to them. With the few gifts which Nature has beſtowed on them, they remain ſatisfied, and live happily among their mountains and their ſtorms. If ſouthern nations afford examples of people who feed nearly on vegetables alone, the Laplanders furniſh one of the oppoſite extreme; for they are almoſt entirely carnivorous animals.

To Norway, Sweden, Germany, and Britain, the ſame obſervation is applicable. In theſe countries, animal food is much more uſed than in France, Spain, Italy, Barbary, and the other ſouthern regions of the globe. Many reaſons may be aſſigned for theſe differences in the food of nations. The natural productions of the earth depend entirely on the climate. In warm climates, the vegetables which grow ſpontaneouſly are both more luxuriant and more various. The number and richneſs of their fruits far exceed thoſe of colder regions. From this circumſtance, the natives muſt be ſtimulated to uſe a proportionally greater quantity of vegetable food; and we learn from hiſtory, and from travellers, that this is actually the caſe. In cold countries, on the contrary, vegetables are not only fewer, but more rigid, and contain leſs nouriſhment. The inhabitants, accordingly, are obliged to live principally on animal ſubſtances. If we examine the mode of feeding in different nations, it will be found, that, in proportion as men approach or recede from the poles, a greater or leſs quantity of animal and vegetable ſubſtances are uſed in their diet. Cuſtom, laws, and religious rites, it muſt be allowed, produce conſiderable differences in the articles of food, among particular nations, which have no dependence on climate, or the natural

productions

productions of the earth. But, when men are not fettered or prejudiced by extraneous circumſtances, or political inſtitutions, the nature of their food is invariably determined by the climates they inhabit. The variety of food, in any country, is likewiſe greatly influenced by culture, and by imitation. Commerce occaſionally furniſhes new ſpecies of food, particularly of the vegetable kind. In Scotland, till about the beginning of this century, the common people lived almoſt entirely upon grain. Since that period, the culture and uſe of the potato, of many ſpecies of coleworts, and of fruits, have been introduced, and univerſally diffuſed through the nation.

Whether man was originally intended by Nature to live ſolely upon animal or vegetable food, is a queſtion which has been much agitated both by the ancients and the moderns. Many facts and circumſtances concur in eſtabliſhing the opinion, that man was deſigned to be nouriſhed neither by animals nor vegetables ſolely, but by a mixture of both. Agriculture is an art, the invention of which muſt depend on a number of fortuitous circumſtances. It requires a long ſucceſſion of ages before ſavage nations learn this art. They depend entirely for their ſubſiſtence upon hunting wild animals, fiſhing, and ſuch fruits as their country happens ſpontaneouſly to produce. This has uniformly been the manner of living among all the ſavage nations of which we have any proper knowledge; and ſeems to be a clear proof, that animal food is by no means repugnant to the nature of man. Beſides, the ſurface of the earth, even in the moſt luxuriant climates, and though aſſiſted by culture, is not capable of producing vegetable food in ſufficient quantity to ſupport the human race, after any region of it has become ſo populous as Britain, France, and many other nations. The general practice of mankind, when not reſtrained by prejudice or ſuperſtition, of feeding promiſcuouſly on animal and vegetable ſubſtances, is a ſtrong indication that man is, partly at leaſt, a carnivorous animal. The Gentoos, though their chief diet be vegetables, afford no proper argument againſt this reaſoning. They are obliged, by their religion, to abſtain from the

flesh of animals; and they are allowed to use milk, which is a very nourishing animal food. Notwithstanding this indulgence, the Gentoos, in general, are a meagre, sickly, and feeble race. In hot climates, however, a very great proportion of vegetable diet may be used without any bad consequences.

Other arguments, tending to the same conclusion, are derived, not from the customs or practices of particular nations, but from the structure of the human body. All animals which feed upon vegetables alone, as formerly remarked, have stomachs and intestines proportionally larger than those that live solely on animal substances. Man, like the carnivorous tribes, is furnished with cutting and canine teeth, and, like the graminivorous, with a double row of grinders. The dimensions of his stomach and intestines likewise hold a mean proportion between these two tribes of animals, which differ so essentially in their characters and manners.—From these, and similar arguments, I have no hesitation to conclude, that a promiscuous use of animal and vegetable substances is no deviation from the original nature or destination of mankind, whatever country they may inhabit.

With regard to the different proportions of animal and vegetable food which are most accommodated to the health and vigour of mankind, no general rule can be given that could be applicable to different climates, and to the different constitutions of individuals. Animal food, it is certain, gives vigour to the body, and may be used more liberally by the active and laborious than by those who lead a studious and sedentary life. A great proportion of vegetable food, and particularly of bread, is considered, by the most eminent physicians, as best adapted for men who are fond of science and literature; for, full meals of animal food load the stomach, and seldom fail to produce dulness, yawning, indolence, and many diseases which often prove fatal.

The remainder of this chapter, from unavoidable causes, must consist of observations of a more desultory kind.

Most animals, when they live long on a particular species of food, are apt to be affected with diseases, which generally

generally ariſe from coſtiveneſs, or its oppoſite. The Guiney-pigs, after being confined for ſome time to cole-worts, contract a looſeneſs, which often terminates in death. But, when thoſe animals are at full liberty, they prevent this effect, by an inſtinct which teaches them to make frequent changes from moiſt to dry food: If they are reſtrained in their choice, they will eat, as a ſuccedaneum, paper, linen, and even woollen cloths.

Though ſome animals, and many vegetables, would be noxious to man, if uſed as food, yet, in general, that matter is more regulated by chance and cuſtom than by rational motives. By experience, and the aid of our ſenſes, we acquire a tolerable facility of diſtinguiſhing ſalutary from noxious food. Other animals ſelect their food inſtinctively; and their choice is chiefly determined by the ſenſe of ſmelling. The ſpaniel hunts his prey by the ſcent; but the grey-hound depends principally upon the uſe of his eye. When the grey-hound loſes ſight of a hare, he inſtantly gives up the chace, and looks keenly around him, but never applies his noſe, in order to diſcover the track. Some rapacious animals, as wolves and ravens, diſcover carrion at diſtances, which, if we were to judge from our own ſenſe of ſmelling, would appear to be altogether incredible. Others, as eagles, hawks, gulls, &c. ſurpriſe us no leſs by the acuteneſs of their ſight. They perceive, from great heights in the air, mice, ſmall birds, and minute fiſhes in the water.

One great cauſe of the diffuſion of animals over every part of the globe, is to be derived from the diverſity of appetites for particular ſpecies of food, implanted by Nature in the different tribes. Some fiſhes are only to be found in certain latitudes. Some animals inhabit the frigid, others the torrid zones; ſome frequent deſarts, mountains, woods, lakes, and meadows. In their choice of ſituation, they are uniformly determined to occupy ſuch places as furniſh them with food accommodated to their natures. Monkeys, the elephant, and rhinoceros, fix on the torrid zone, becauſe they feed on vegetables which flouriſh there during the whole year. The rein-deer inhabit the cold regions of the north, becauſe theſe coun-

tries produce the greateſt quantity of the lichen, a ſpecies of moſs, which is their beloved food. The pelican makes choice of dry and deſert places to lay her eggs. When her young are hatched, ſhe is obliged to bring water to them from great diſtances. To enable her to perform this neceſſary office, Nature has provided her with a large ſac, which extends from the tip of the upper mandible of her bill to the throat, and holds as much water as will ſupply her brood for ſeveral days. This water ſhe pours into the neſt to cool her young, to allay their thirſt, and to teach them to ſwim. Lions, tigers, and other rapacious animals, reſort to theſe neſts, drink the water, and are ſaid not to injure the young*. The goat aſcends the rocky precipice, to crop the leaves of ſhrubs, and other favourite plants. The ſloth and the ſquirrel feed upon the leaves and the fruit of trees, and are, therefore, furniſhed with feet which enable them to climb. Water-fowls live upon fiſhes, inſects, and the eggs of fiſhes. Their bill, neck, wings, legs, and whole ſtructure, are nicely fitted for enabling them to catch the food adapted to their natures. Their feeding upon the eggs of fiſhes accounts for that variety of fiſhes which are often found in lakes and pools on the tops of hills, and on high grounds remote from the ſea and from rivers. The bat and the goat-ſucker fly about during the night, when the whole air is filled with moths, and other nocturnal inſects. The bear, who acquires a prodigious quantity of fat during the ſummer, retires to his den, when proviſions fail him, in winter. For ſome months, he receives his ſole nouriſhment from the abſorption of the fat which had been previouſly accumulated in the cellular membrane.

A glutton †, brought from Siberia to Dreſden, eat every day, ſays M. Klein, thirty pounds of fleſh without being ſatisfied. This fact indicates an amazing digeſtive power in ſo ſmall a quadruped; for the ſtory of his ſqueezing his ſides between two trees, in order to make him diſgorge, is a mere fable ‡.

Siberia, Kamtſchatka, and the polar regions, are ſuppoſed

* Amoen. Acad. vol. 2. p. 41. S.

† The Muſtela *Gulo* of Linnæus; the Gulo of Dr. Pallas.

‡ Gaz. Litteraire, vol. 1. p. 481. S.

posed to be the abodes of misery and desolation. They are, it must be allowed, infested with numerous tribes of bears, foxes, gluttons, and other rapacious animals. But, it should be considered, that these voracious animals supply the natives with both food and clothing. To elude the attacks of ferocity, and to acquire possession of the skins and carcases of such creatures, the industry and dexterity of savage nations are excited. The furs are demanded by foreigners. The inhabitants by this means learn commerce and the arts of life; and, in the progress of time, bears and wild beasts become the instruments of polishing a barbarous people. Thus, the most substantial good often proceeds from apparent misfortune.

There is hardly a plant that is not rejected as food by some animals, and ardently desired by others. The horse yields the common water-hemlock ‡ to the goat, and the cow the long-leafed water-hemlock || to the sheep. The goat, again, leaves the aconite §, or bane-berries, to the horse, &c. Plants which afford proper nourishment to some animals, are by others avoided, because they would not only be hurtful, but even poisonous. Hence no plant is absolutely deleterious to animal life. Poison is only a relative term. The euphorbia, or spurge, so noxious to man, is greedily devoured by some of the insect tribes.

It is a maxim universally received, that every animal, after birth, grows, or acquires an augmentation of size. The spider-fly, however, affords an exception. The mother lays an egg so disproportionally large, that no person, without the aid of experience, could believe it to have been produced by this insect. When the egg is hatched, a fly proceeds from it, which, at the moment of birth, equals the parent in magnitude. Upon a stricter examination of this egg, it has been discovered, that the insect, while in the belly of its mother, undergoes a transformation into the nympth or chrysalis state; and that, instead of a worm, a fly is produced from it, of the same dimensions as the parent. This discovery, however, does not diminish our wonder, that any animal should actually give birth to a substance as large as its own

‡ Phellandrium *aquaticum*. || Cicuta *virosa*. § Aconitum *Napellus*.

own body, and that its ſize ſhould never afterwards receive any augmentation ¶.

When caterpillars, ſome time before their change, are deprived of food, they diminiſh to at leaſt one half of their former ſize. Their chryſalids, of courſe, as well as the butterflies which proceed from them, are proportionally ſmall. From this fact we learn the importance of feeding all young animals well till they acquire their full growth.

It is a remark of the ingenious Reaumur, that ſuch inſects as feed upon dead carcaſes, and whoſe fecundity is great, never attack live animals. The fleſh-fly depoſits her eggs in the bodies of dead animals, where her progeny receive that nouriſhment which is beſt ſuited to their conſtitution. But this fly never attempts to lay her eggs in the fleſh of ſound and living animals. If Nature had determined her to obſerve the oppoſite conduct, men, quadrupeds, and birds, would have been dreadfully afflicted by the ravages of this ſingle inſect. Leſt it might be imagined that the fleſh-fly ſelected dead, inſtead of live animals, becauſe, in depoſiting her eggs, ſhe was unable to pierce the ſkin of the latter, M. de Reaumur made the following experiment, which removed every doubt that might ariſe on the ſubject. He carefully pulled off all the feathers from the thigh of a young pigeon, and applied to it a thin ſlice of beef, in which there were hundreds of maggots. The portion of beef was not ſufficient to maintain them above a few hours. He fixed it to the thigh by a bit of gauze; and he prevented the pigeon from moving, by tying its wings and legs. The maggots ſoon ſhewed that their preſent ſituation was diſagreeable to them. Moſt of them retired from under the ſlice of beef; and the few that remained periſhed in a ſhort time. Their death was probably occaſioned by the degree of heat in the pigeon's body being greater than their conſtitution could bear. Upon the ſame pigeon M. de Reaumur performed another experiment. He took off the ſkin from its thigh, laid bare the fleſh, and applied immediately another ſlice of beef full of maggots. The animals

¶ Reaumur, tom. 5. p. [illegible]; — and Bonnet, tom. [illegible] p. [illegible]

animals diſcovered evident marks of uneaſineſs; and all of them that remained on the fleſh of the pigeon were deprived of life, as in the former experiment, in leſs than an hour. Thus the degree of heat that is neceſſary to ſuch worms as inhabit the interior parts of animals, is deſtructive to thoſe ſpecies which Nature has deſtined to feed upon the fleſh of dead animals. Hence the worms ſometimes found in ulcerous ſores, muſt belong to a different ſpecies from thoſe upon which the above experiments were made.

The growth of ſome worms, which feed upon animal or vegetable ſubſtances, is extremely rapid. Redi remarked, that theſe creatures, the day after they eſcaped from the egg, had acquired at leaſt double their former ſize. At this period he weighed them, and found that each worm weighed ſeven grains; but that, on the day preceding, it required from twenty-five to thirty of them to weigh a ſingle grain. Hence, in about the ſpace of twenty-four hours, each of theſe worms had become from 155 to 210 times heavier than formerly. This rapidity of growth is remarkable in thoſe maggots which are produced from the eggs of the common fleſh-fly.

Before we diſmiſs this ſubject, a few obſervations on that power, inherent in all animal bodies, of diſſolving, and converting into chyle, every nutritive ſubſtance thrown into the ſtomach, merit attention.

In order to explain the proceſs of digeſtion, ſome phyſicians and philoſophers have had recourſe to mechanical force, and others to chemical action. The ſupporters of mechanical force maintained, that the ſtomachs of all animals comminuted, or broke down into ſmall portions, every ſpecies of food, and prepared it for being converted into chyle. The chemical philoſophers, on the contrary, ſupported the opinion, that the food was diſſolved by a fermentation induced by the ſaliva and gaſtric juices. The diſputes which naturally aroſe from theſe ſeemingly oppoſite theories, ſtimulated the inquiries of the ingenious, and produced ſeveral curious and important diſcoveries. Reaumur, M'Bride, Stevens, Spallanzani, Hunter, have all exerted their induſtry and talents upon this ſubject.

ject. To give even an abridged view of their different labours would be tedious, and, at the same time, would not coincide with the design of this work. I shall, therefore, confine myself to some results of their experience and labours. Spallanzani, who is a voluminous writer on this subject, relates not only the discoveries of his predecessors, but has enriched his work with numerous experiments and observations made by himself. In his investigation of the process of digestion, and the action of the stomach, he observes the following order:

1. He treats of animals with strong muscular stomachs, as common fowls, turkeys, ducks, geese, pigeons, &c. 2. Of animals with stomachs of an intermediate consistence, as crows, herons, &c. 3. Of animals with membranous stomachs, as frogs, lizards, earth and water snakes, vipers, fishes, sheep, the ox, the horse, the owl, the falcon, the eagle, the cat, the dog, man, &c.

With regard to birds which are furnished with muscular stomachs, or gizzards, Spallanzani, in imitation of Reaumur, procured small glass and metal balls and tubes, perforated with many holes. These he filled with different kinds of food, and forced them down the throats of common fowls, turkeys, &c. He filled balls with barley, or other grains, in their entire state, and allowed them to remain in the stomachs of ducks, turkeys, and other fowls, for twenty-four, and, in some cases, for forty-eight hours. He then killed the animals, took the balls out of their stomachs, and, after examining the grains attentively, he could not discover that the gastric juice, to the action of which they were fully exposed by the numerous holes in the balls, had made the smallest impression upon them. They suffered no diminution of size, and exhibited no marks of dissolution. These experiments he often repeated upon a number of fowls provided with muscular stomachs, and the event was uniformly the same: In no instance did the gastric juice produce any solvent effect upon the grain contained in the balls. After these unsuccessful attempts, he suspected, that, though the gastric juice was unable to dissolve grains in their entire state, it might act as a menstruum upon them when sufficiently

ficiently maſticated or bruiſed. To aſcertain this point, he afterwards filled his balls with bruiſed grains, and introduced them into the ſtomachs of different fowls, as cocks, ducks, turkeys, wood-pigeons, &c. In all the numerous trials he made with bruiſed grain, he invariably found, that the grain was more or leſs diſſolved in proportion to the time the balls were allowed to remain in the ſtomach.

Reaumur and Spallanzani, in the courſe of their experiments upon the digeſtion of birds with muſcular ſtomachs, diſcovered a wonderful comminuting force which theſe ſtomachs poſſeſs. When tin tubes full of grain were thrown into the ſtomachs of turkeys, and allowed to continue there a conſiderable time, they were found to be broken, cruſhed, or diſtorted, in a moſt ſingular manner. 'Having found,' ſays Spallanzani, 'that the tin tubes 'which I uſed for common fowls were incapable of re'ſiſting the ſtomach of turkeys, and not happening at 'that time to be provided with any tin plate of greater 'thickneſs, I tried to ſtrengthen them, by ſoldering to 'the ends two circular plates of the ſame metal, perfo'rated only with a few holes for the admiſſion of the 'gaſtric fluid. But this contrivance was ineffectual; for 'after the tubes had been twenty hours in the ſtomach of 'a turkey, the circular plates were driven in, and ſome 'of the tubes were broken, ſome compreſſed, and ſome 'diſtorted, in the moſt irregular manner *.'

The ſmooth and blunt ſubſtances formerly employed, Spallanzani remarks, though ſo violently acted upon, could not injure the ſtomach; he therefore tried what effects would be produced by ſharp bodies thrown into the gizzards of fowls. He found that the ſtomach of a cock, in the ſpace of twenty-four hours, broke off the angles of a piece of rough jagged glaſs. Upon examining the gizzard, no wound or laceration appeared. 'Twelve 'ſtrong tin needles,' ſays Spallanzani, 'were firmly fixed 'in a ball of lead, the points projecting about a quarter 'of an inch from the ſurface. Thus armed, it was co'vered with a caſe of paper, and forced down the throat 'of a turkey. The bird retained it for a day and a half

'without

* Spallanzani's Diſſertations, vol. 1. p. 12. S.

'without ſhowing the leaſt ſymptom of uneaſineſs. Why
'the ſtomach ſhould have received no injury from ſo
'horrid an inſtrument I cannot explain: The points of
'the twelve needles were broken off cloſe to the ſurface
'of the ball, except two or three, of which the ſtumps
'projected a little higher.—Two of the points of the
'needles were found among the food; the other ten I
'could not diſcover, either in the ſtomach or the long
'track of the inteſtines; and therefore concluded, that
'they had paſſed out at the vent †.'

The ſame author made a ſecond experiment ſeemingly ſtill more cruel. He fixed twelve ſmall lancets, very ſharp both at the points and edges, in a ſimilar ball of lead. 'The lancets,' ſays he, 'were ſuch as I uſe for 'the diſſection of ſmall animals. The ball was given to 'a turkey cock, and left eight hours in the ſtomach; at 'the expiration of which time that organ was opened; 'but nothing appeared except the naked ball, the twelve 'lancets having been broken to pieces. I diſcovered three 'of them in the large inteſtines, pointleſs, and mixed 'with the excrements; the other nine were miſſing, and 'had probably been voided at the vent. The ſtomach 'was as ſound and entire as that which had received the 'needles. Two capons, of which one was ſubjected to 'the experiment with the needles, and the other with the 'lancets, ſuſtained them equally well.'

The ſmall ſtones ſo commonly found in the ſtomachs of many of the feathered tribes, have been ſuppoſed to ſheath the gizzard, and to enable it to digeſt, or at leaſt to break down into ſmall fragments, glaſs, iron, wood, ſtones, and other hard, and even ſharp-pointed, ſubſtances. Spallanzani has endeavoured to prove, that the muſcular action of the gizzard is equally powerful, whether the ſmall ſtones are preſent or abſent. To aſcertain this point, he took wood-pigeons the moment they eſcaped from the egg, fed and nurſed them himſelf till they were able to peck: 'They were then,' continues our author, 'confined in a cage, and ſupplied at firſt with vetches 'ſoaked in warm water, and afterwards in a dry and hard 'ſtate.

† Spallanzani's Diſſertations, vol. 1. p. 18. S.

'ſtate. In a month after they had begun to peck, hard 'bodies, ſuch as tin tubes, glaſs globules, and fragments 'of broken glaſs, were introduced with the food. Care 'was taken that each pigeon ſhould ſwallow only one of 'theſe ſubſtances. In two days afterwards they were 'killed. Not one of the ſtomachs contained a ſingle 'pebble; and yet the tubes were bruiſed and flattened, 'and the ſpherules and bits of glaſs blunted and broken: 'This happened alike to each body; nor did the ſmalleſt 'laceration appear on the coats of the ſtomach.' From ſeveral experiments of a ſimilar nature, and accompanied with the ſame events, Spallanzani concludes this ſubject with that candour which is always a genuine characteriſtic of a real philoſophic ſpirit. Upon the whole, 'it 'appears,' ſays he, 'that theſe ſmall ſtones are not at all 'neceſſary to the trituration of the firmeſt food, or the 'hardeſt foreign ſubſtance, contrary to the opinion of 'many anatomiſts and phyſiologiſts, as well ancient as 'modern. I will not, however, deny that, when put in 'motion by the gaſtric muſcles, they are capable of producing ſome effect on the contents of the ſtomach.'

The celebrated Mr. John Hunter, in his *Obſervations on Digeſtion* *, fairly quotes the modeſt concluſion of Spallanzani. But, he inſiſts that ſtones are extremely uſeful in the comminution of grain, and other ſubſtances, which conſtitute the food of many fowls. 'In conſidering,' Mr. Hunter remarks, 'the ſtrength of the gizzard, and 'its probable effects when compared with the human ſtomach, it muſt appear that the gizzard is, in itſelf, very 'fit for trituration. We are not, however, to conclude, 'that ſtones are entirely uſeleſs; for, if we compare the 'ſtrength of the muſcles of the jaws of animals who 'maſticate their food, with thoſe of birds who do not, 'we ſhall ſay, that the parts are well calculated for the 'purpoſe of maſtication; yet we are not from thence to 'infer, that the *teeth* in ſuch jaws are uſeleſs, even although we have proof that the *gums* do the buſineſs 'when the teeth are gone. If ſtones are of uſe, which 'we may reaſonably conclude they are, birds have an

* Page 156.

'advantage over animals having teeth, so far as stones are
'*always* to be found, while the teeth are not renewed.—
'If we constantly find in an organ substances which can
'only be subservient to the functions of that organ, should
'we deny them that use, although the part can do its
'office without them?—The stones assist in grinding down
'the grain, and, by separating its parts, allow the gastric
'juice to come more readily in contact with it.'

The next series of experiments were made upon animals with what Spallanzani denominates intermediate stomachs between the muscular and membranous, as ravens, crows, herons, &c. The power and action of these intermediate stomachs are superior to those of the membranous kind, but greatly inferior to those of the muscular. The tin tubes, or balls, which pigeons and turkeys soon flatten and disfigure, remain unaltered in the stomach of crows. Their gastric muscles, however, are by no means inert. Though they are unable to compress or distort tin tubes, they are capable of producing this effect upon thin tubes of lead. Birds whose stomachs are of an intermediate kind, with regard to the thickness and strength of their muscular coats, may be denominated *omnivorous*. They eat grass, herbs, grain, and flesh of every kind. When we make experiments upon the digestive powers of gallinaceous birds, the animals must be killed before we can learn what effects have been produced on the substances inclosed in the balls or tubes. But, on crows and ravens, experiments of this kind may be repeated as often as we please, without destroying a single individual. Substances which they are incapable of digesting, as metallic tubes, they have the power of disgorging, or returning by the mouth, in the same manner as falcons, and other birds of prey, throw up the feathers and hair of the animals they have devoured. In birds of prey, this vomiting is commonly performed every twenty-four hours; but, in crows, it happens at least every nine, and not unfrequently every two or three hours.

Spallanzani, as in the former experiments, thrust down perforated tubes, filled with different substances, into the stomachs of crows. These tubes were uniformly thrown

up by the animals in a few hours. When the tubes were filled with entire grains, as wheat or beans, he found that the gaſtric juice, though the tubes, by being repeatedly forced down, continued in the ſtomach for the ſpace of forty-eight hours, had exerted no ſolvent power. As the huſks of the ſeeds reſiſted the action of the gaſtric juice, he bruiſed them, and repeated the experiment. 'Four 'tubes full of this coarſe flour,' ſays he, 'were given to 'a crow: They remained eight hours in the ſtomach, 'and proved the juſtneſs of my ſuſpicion; for, upon exa-'mining the contents, I found above a fourth part want-'ing. This could ariſe from no other cauſe but ſolution 'in the gaſtric liquor, with which the remainder was fully 'impregnated. Another obſervation concurred in prov-'ing the ſame propoſition: The largeſt bits of wheat and 'bean were evidently much dimiſhed. This muſt have been 'owing to the gaſtric liquor having corroded and diſſolved 'good part of them, as the nitrous acid, diluted with a 'large quantity of water, gradually conſumes calcareous 'ſubſtances. I replaced what remained of the ſeeds in the 'tubes, and committed them again to the ſtomach, where-'in they remained, at different intervals, twenty-one 'hours; at the end of which period they were entirely 'diſſolved; nothing being left but ſome pieces of huſk, 'and a few inconſiderable fragments of the ſeeds. Wheat 'and beans floating looſe in the cavity of the ſtomach, 'undergo the ſame alteration as in the tubes. When I 'fed my crows with theſe ſeeds, I obſerved, that, before 'they ſwallowed them, they ſet them under their feet, and 'reduced them to pieces by repeated ſtrokes of their long 'and heavy beaks: And now they digeſted them very 'well; nay, this proceſs was very rapid in compariſon of 'that which took place within the tubes. But, when the 'birds, either from exceſſive hunger, or violence, ſwallow-'ed the ſeeds entire, the greateſt part of them paſſed out 'entire at the anus, or were vomited. We cannot, there-'fore, be ſurpriſed, that the gaſtric juice could not diſſolve 'them within the tubes, ſince it was incapable of effect-'ing this proceſs within the cavity of the ſtomach, where 'its ſolvent power is far ſuperior.'

Similar

Similar experiments were made with French beans, peaſe, nut-kernels, bread, apples, and different kinds of fleſh and fiſh, all of which were diſſolved, both in tubes, and in the cavity of the ſtomach, by the gaſtric juice.

Spallanzani finiſhes his experiments on digeſtion with thoſe animals which have thin membranous ſtomachs. This claſs comprehends an immenſe number of ſpecies, as man, quadrupeds, fiſhes, reptiles. In theſe, the coats of the ſtomach ſeem to have little or no action upon their contents, the gaſtric juice being fully ſufficient to break down the food, and reduce it to a pulp.

With regard to man, Dr. Stevens, in an Inaugural Diſſertation concerning Digeſtion, publiſhed at Edinburgh in the year 1777, made ſeveral experiments upon a German, who gained a miſerable livelihood by ſwallowing ſtones for the amuſement of the people. He began this ſtrange practice at the age of ſeven, and had at that time continued it about twenty years. He ſwallowed ſix or eight ſtones at a time, ſome of them as large as a pigeon's egg, and paſſed them in the natural way. Dr. Stevens thought this poor man would be an excellent ſubject for aſcertaining the ſolvent power of the gaſtric juice in the human ſtomach. The Doctor, accordingly, made uſe of him for this purpoſe. He made the German ſwallow a hollow ſilver ſphere, divided into two cavities by a partition, and perforated with a great number of holes, capable of admitting an ordinary needle. Into one of theſe cavities he put four ſcruples and a half of raw beef, and into the other five ſcruples of raw bleak. In twenty-one hours the ſphere was voided, when the beef had loſt a ſcruple and a half, and the fiſh two ſcruples. A few days afterwards, the German ſwallowed the ſame ſphere, which contained, in one cavity, four ſcruples and four grains of raw, and, in the other, four ſcruples and eight grains of boiled beef. The ſphere was returned in forty-three hours: The raw fleſh had loſt one ſcruple and two grains, and the boiled one ſcruple and ſixteen grains. Suſpecting that, if theſe ſubſtances were divided, the ſolvent would have a freer acceſs to them, and more of them would be diſſolved, Dr. Stevens procured another ſphere, with holes large enough

enough to receive a crow's quill. He incloſed ſome beef in it a little maſticated. In thirty-eight hours after it was ſwallowed, it was voided quite empty. Perceiving how readily the chewed meat was diſſolved, he tried whether it would diſſolve equally ſoon without being chewed. With this view, he put a ſcruple and eight grains of pork into one cavity, and the ſame quantity of cheeſe into the other. The ſphere was retained in the German's ſtomach and inteſtines forty-three hours; at the end of which time, not the ſmalleſt quantity of either pork or cheeſe was to be found in the ſphere. He next ſwallowed the ſame ſphere, which contained, in one partition, ſome roaſted turkey, and ſome boiled ſalt herring in the other. The ſphere was voided in forty-ſix hours; but no part of the turkey or herring appeared; for both had been completely diſſolved. Having diſcovered that animal ſubſtances, though incloſed in tubes, were eaſily diſſolved by the gaſtric juice, the Doctor tried whether it would produce the ſame effect upon vegetables. He, therefore, incloſed an equal quantity of raw parſnip and potato in a ſphere. After continuing forty-eight hours in the alimentary canal, not a veſtige of either remained. Pieces of apple and turnip, both raw and boiled, were diſſolved in thirty-ſix hours.

It is a comfortable circumſtance, that no animal, perhaps, except thoſe worms which are hatched in the human inteſtines, can reſiſt the diſſolving power of the gaſtric juice. Dr. Stevens incloſed live leeches, and earth-worms, in different ſpheres, and made the German ſwallow them. When the ſpheres were diſcharged, the animals were not only deprived of life, but completely diſſolved, by the operation of this powerful menſtruum. Hence, if any live reptile ſhould chance to be ſwallowed, we have no reaſon to apprehend any danger from ſuch an accident.

The German left Edinburgh before the Doctor had an opportunity of making a farther progreſs in his experiments. He therefore had recourſe to dogs and ruminating animals. In the courſe of his trials upon the ſolvent power in the gaſtric fluid of dogs, he found that it was capable of diſſolving hard bones, and even balls of ivory;

but

but that, in equal times, very little impreſſion was made upon potatoes, parſnip, and other vegetable ſubſtances. On the contrary, in the ruminating animals, as the ſheep, the ox, &c. he diſcovered, that their gaſtric juice ſpeedily diſſolved vegetables, but made no impreſſion on beef, mutton, and other animal bodies. From theſe laſt experiments, it appears, that the different tribes of animals are not leſs diſtinguiſhed by their external figure, and by their manners, than by the quality and powers of their gaſtric juices. Dogs are unable to digeſt vegetables, and ſheep and oxen cannot digeſt animal ſubſtances. As the gaſtric juice of the human ſtomach is capable of diſſolving, nearly with equal eaſe, both animals and vegetables, this circumſtance affords a ſtrong, and almoſt an irreſiſtible, proof, that Nature originally intended man to feed promiſcuouſly upon both.

Live animals, as long as the vital principle remains in them, are not affected by the ſolvent powers of the ſtomach. 'Hence it is,' Mr. Hunter remarks, 'that we 'find animals of various kinds living in the ſtomach, or 'even hatched and bred there; but the moment that any 'of theſe loſe the living principle, they become ſubject to 'the digeſtive powers of the ſtomach. If it were poſſible, 'for example, for a man's hand to be introduced into 'the ſtomach of a living animal, and kept there for ſome 'conſiderable time, it would be found, that the diſſolvent 'powers of the ſtomach could have no effect upon it: But, 'if the ſame hand were ſeparated from the body, and 'introduced into the ſame ſtomach, we ſhould then find, 'that the ſtomach would immediately act upon it. Indeed, if this were not the caſe, we ſhould find that 'the ſtomach itſelf ought to have been made of indigeſtible materials; for, if the living principle was not capable of preſerving animal ſubſtances from undergoing 'that proceſs, the ſtomach itſelf would be digeſted. But 'we find, on the contrary, that the ſtomach, which at 'one inſtant, that is, while poſſeſſed of the living principle, was capable of reſiſting the digeſtive powers which 'it contained, the next moment, viz. when deprived of 'the living principle, is itſelf capable of being digeſted,

'either

'either by the digeſtive powers of other ſtomachs, or by 'the remains of that power which it had of digeſting 'other things.'

When bodies are opened ſome time after death, a conſiderable aperture is frequently found at the greateſt extremity of the ſtomach. 'In theſe caſes,' ſays Mr. Hunter, 'the contents of the ſtomach are generally found 'looſe in the cavity of the abdomen, about the ſpleen 'and diaphragm. In many ſubjects, this digeſtive power 'extends much farther than through the ſtomach. I have 'often found, that, after it had diſſolved the ſtomach at 'the uſual place, the contents of the ſtomach had come 'into contact with the ſpleen and diaphragm, had partly 'diſſolved the adjacent ſide of the ſpleen, and had diſ-'ſolved the ſtomach quite through; ſo that the contents 'of the ſtomach were found in the cavity of the thorax, 'and had even affected the lungs in a ſmall degree.'

CHAPTER IX.

Of the Sexes of Animals and Vegetables.

SECTION I.

Of the Sexes of Animals.

ALL the larger and more perfect animals are diſtinguiſhed by the ſexes of male and female. The bodies of males, though not without exceptions, are, in general, ſtronger, larger, and more active, than thoſe of the females. In the human ſpecies, the male is not only larger than the female, but his muſcular fibres are firmer and more compact, and his whole frame indicates a ſuperior ſtrength and robuſtneſs of texture. He does not acquire his

his full growth, and best form, till he arrives at the age of thirty years. But, in women, the parts are rounder, and their muscular fibres more feeble and lax than those of men, and their growth and form are perfect at the age of twenty. A similar observation is applicable to the minds of the two sexes. Man is, comparatively, a bold, generous, and enterprising animal. Women, on the contrary, are timid, jealous, and disposed to actions which require less agility and strength. Hence, they are entitled to claim, and, by their amiable weaknesses, they actually receive, our protection. Men are endowed with majesty of figure and force of mind; but beauty, and the graces, are the proper characteristics of women. The laxity and softness of their texture may, in some measure, account for the timidity and listlessness of their disposition; for, when the bodies of men are relaxed by heat, or by any other cause, their minds become not only timid, but weak, undetermined, and inactive.

The social intercourse of women softens the dispositions, and soothes the cares and labours of the men. Their little female humours, caprices, and follies, give rise to many exertions of virtue. They excite in us compassion, humanity, and tenderness of affection. The delicacy of their bodies, and the weakness of their minds, require our support and protection. In return, the gentle and insinuating manners of the women have a direct tendency to soften and smooth the natural roughness of men. In most governments, women have the entire management and training of children, till their characters and dispositions are almost fixed for life. This is an important office; and would require more education and sense than they commonly receive either from nature or art. But, their persevering and unremitting attention to their charge, especially when children are sick or weakly, is so truly astonishing, that no man could have patience to perform the laborious and painful task. Women are likewise said to suffer bodily pain with more resolution than men. Women reason rapidly; but their reasoning, though often acute, is seldom solid.

Modesty is one of the most distinguishing and attractive charac-

characteriſtics of the female ſex. This is the great defence with which Nature has armed them againſt the artifices and deceit of the males. Modeſty has a double effect: It both attracts and repels. It heightens the deſire of the male, and deters him from rudeneſs, or improper behaviour. Were women deprived of this amiable quality, all their charms would vaniſh, and the ardour of love would be extinguiſhed. It is, therefore, not only the intereſt of females to cultivate modeſty, but to guard, with the moſt anxious attention, againſt the ſmalleſt encroachments. Every attack, however apparently inſignificant, ſhould be repelled with ſpirit and intrepidity. To men of ſenſibility, a ſingle glance of the eye will tell them their conduct is improper, and make them not only inſtantly deſiſt, but prevent any future attempt. There is no part of the female character which men revere ſo much as modeſty. It is the brighteſt and moſt valuable jewel with which a woman can be adorned. A fine woman without modeſty, inſtead of gaining the affections of men, becomes an object of contempt, and even of diſguſt. It is equally the intereſt of men to cheriſh, and not to injure by indelicacy, a quality from which they derive ſo much pleaſure and advantage.

It is not unworthy of remark, that modeſty is by no means confined to the human ſpecies. Evident traces of it are diſcoverable in the brute creation. Even ſo low as the inſect tribes, moſt females repel the firſt attacks of the males. If this is not modeſty, it has all the effects of it; for it heightens the reſpect and affection of the males, and makes them employ every alluring art to procure the regard of the female.

It is a curious fact, that moſt carnivorous quadrupeds are more averſe from devouring women than men. The bears of Kamtſchatka follow the women, when gathering wild fruits in the woods, and, though moſt rapacious animals, do them no farther harm than robbing them of part of the fruit *. The aſpect of man being more bold, may, perhaps, create an idea of competition and danger, and excite the ferocity and courage of the animal. There

* Gazette Literaire, vol. 1. p. 482. S.

ſeems to be an inſtinctive reſpect, if not dread, of the human kind implanted in moſt animals. If this be the caſe, the above fact amounts to a high compliment to the women; for they receive more favour from the brute creation than men.

With regard to animals, in general, the intercourſe of ſexes is neceſſary for the multiplication of the ſpecies. But, as formerly remarked *, ſeveral of the lower tribes are enabled to multiply without the intervention of the ſexes. In ſome animals, both ſexes are combined in each individual. The earth-worm, ſnails, and ſeveral ſhell-fiſhes, are hermaphrodites; and yet the conjunction of two is neceſſary for their multiplication. Mr. Adanſon, in his Account of Senegal, mentions ſome ſhell-animals which, in order to produce, require the union of three individuals. In the polypus, no appearance of ſexual diſtinction has hitherto been diſcovered. Nature, however, has not denied them the power of multiplication, which is effected in a very ſingular manner †. Caterpillars of every denomination are totally deſtitute of ſexes, and are incapable, while they remain in that ſtate, of multiplying their ſpecies. But, after their transformation into flies, the diſtinction of ſexes is apparent, and their fertility is exceedingly great.

Among the larger animals, the difference of ſize and figure between males and females is not remarkable. The moſt ſtriking diſtinctions ariſe from the horns, the tuſks, the creſt, &c. which adorn the head of the male, and are often wanting in the female. But, among the inſect tribes, ſome males differ ſo greatly from the females, that they have the appearance of belonging to a ſeparate genus. In ſome butterflies, for example, the female is deſtitute of wings, while thoſe of the male are very large. The male and female of thoſe animals called *gall-inſects* bear no proportion to each other, either in ſize or in figure. They adhere for ſeveral months to the ſtems and branches of plants, ſhrubs, and trees, without any apparent movement. They have every appearance of galls, being of a ſpherical or oval figure, from which circum-ſtance

* See chap. 1. pag. 24. &c. S. † Ibid. S.

ſtance they have received their denomination, and were long conſidered as vegetable ſubſtances, deſtitute of every degree of animation. Reaumur, however, by a ſtrict examination of the changes they undergo, and of their internal ſtructure, diſcovered that they belong to the animal kingdom. He found that they contained thouſands of ſmall eggs, and that, from theſe eggs, ſmall animals were produced, which ran about with ſome quickneſs, and ſpread themſelves all over the tree, or buſh. After ſome days they attach themſelves to the ſtem and branches, remain immoveable, and gradually increaſe to their full dimenſions, when their bodies are found to contain numbers of eggs. As the perfect animal had no apparent motion, and yet multiplied its ſpecies, it was firſt thought to be an hermaphrodite of a ſingular kind, and that it was capable of producing without any foreign aid. But Reaumur diſcovered that they were impregnated by ſmall flies, and that theſe ſmall flies were male gall-inſects. The head, the body, the breaſt, and the ſix limbs of this fly, are of a deep red colour; and the wings, which are proportionally large, are white, bordered with a band of fine carmine red. In the month of April, he perceived numbers of theſe flies wandering about on the gall-inſects. He obſerved that they pierced the covering of the gall-inſects with a kind of ſting ſhaped like a needle. This circumſtance created a ſuſpicion that theſe flies were the males, and that this was their mode of impregnating the eggs of the female. To aſcertain this point, he opened a number of gall-inſects, which had no uncommon appearance, and, in ſome of them, he found the males, in every ſtage of their exiſtence, till they pierced the external covering, came out in the form of perfect flies, and attached themſelves, as uſual, to the females. The glow-worm, an animal condemned to crawl perpetually on the ſurface of the earth, is a female; and the male, inſtead of a reptile, is a ſcarabæus, or beetle, furniſhed with four wings. A ſpecies of phoſphorus, emitted from the body of the female, excites the attention of this apparently-ſtrange male, who darts down upon her, and actually

actually enables her to continue the kind *. The female of another species of beetle is a perfect reptile, and has not the smallest vestige of wings. But, the male is a real beetle with four wings, and is so disproportioned to the female in size, that their junction should appear to be equally singular as that of a ram with an elephant. With regard to the pucerons, or vine-fretters, the males are winged; but the females remain during life totally destitute of wings. In some species of them, however, the females have wings, and these instruments of motion are denied to the males. Between the size of the male and female pucerons, there is likewise a remarkable disproportion. The males, particularly those which have no wings, are so comparatively small, that they run about, like the male gall-insects, upon the backs of the females. While this exercise continues, which is often very long, the female remains almost motionless. The more insensibility and listlessness shown by the female, the male exhibits the greater ardour and agility. In this situation he passes whole days without taking any nourishment.

In birds of prey, the females are larger, stronger, fiercer, and more beautiful than the males. This superiority of strength and magnitude is conferred on the females, because, in general, they are obliged to procure food both for themselves and for their progeny. Vultures, however, are to be excepted; for the males are equal in size, if they do not exceed that of the females. In the gallinaceous tribe of birds, on the contrary, the males are larger, more beautiful, and more courageous, than the females. The peacock, the turkey, the pheasant, and the dunghill cock, are remarkable examples. Dunghill cocks, especially that kind of them which are called *game-cocks*, are the most intrepidly bold and high-spirited animals in the creation. Nothing but absolute death can make them yield to an antagonist. In the domestic state, at least, this intrepidity, and this daring spirit, result from competition, and jealousy of rivals. Game-cocks, to the disgrace of humanity, are fed and trained with the most scrupulous

* Reaumur. Oeuvres de Bonnet, tom. 2. p. 87. edit. 8vo. S.

ſcrupulous attention. For what purpoſe? For the cruel amuſement and fortuitous emolument of gamblers.

That there are natural hermaphrodites, I have formerly mentioned. But, in man, dogs, cats, unnatural hermaphrodites, if they ever exiſt, are ſo rare, that the celebrated anatomiſt, Mr. Hunter, declares he never ſaw a ſingle example. But, in the horſe, the aſs, black-cattle, and ſheep, he has ſeen many hermaphrodites. It is ſaid to be a known fact, that, when a cow brings forth two calves, one of them a male, and the other a female, the female is incapable of propagation, but that the male is a perfect animal. In England, a cow-calf brought forth with a bull-calf is denominated a *free martin*, and is as well known among farmers as either cow or bull. Mr. Hunter remarks, that a cow-calf, brought forth in the ſituation above mentioned, may be either a free martin or a perfect female. 'For,' he remarks, 'I have reaſon to believe, 'that, in black cattle, ſuch a deviation may be produced 'without the circumſtance of twins; and, even when 'there are twins, the one a male, the other a female, 'they may both have the organs of generation perfectly 'formed *.' What is called a *free martin*, or imperfect hermaphrodite, as far as obſervation has hitherto extended, is confined to black-cattle. The free martin has all the external characteriſtics of a female calf. When animals of this deſcription are preſerved by farmers, it is not for the purpoſe of propagation, but for yoking with the oxen, or fattening for the table. They neither breed, nor, what is curious, do they diſcover the ſmalleſt inclination for the male, nor does the bull pay the leaſt attention to them.

The free martin, in figure, reſembles the ox, or ſpayed heifer. It is conſiderably larger than the bull or cow, and its horns are ſimilar to thoſe of the ox. 'The belly of 'the free martin,' ſays Mr. Hunter, 'is ſimilar to that of 'an ox, having more reſemblance to that of the cow than 'of the bull. Free martins are very ſuſceptible of growing fat with food. The fleſh, like that of the ox, or 'ſpayed heifer, is in common much finer in the fibre than 'either the bull or cow, and is ſuppoſed to exceed that of 'the

* Hunter's Obſervations on the Animal Œconomy. p. 49. S.

'the ox or heifer in delicacy of flavour, and bears a high-'er price at market *.' The Romans seem to have had some knowledge of free martins, though they have not transmitted to us any peculiarities in the structure of these animals. With them, *taurus* was the generic name of the ox kind. They likewise mention *tauræ*, by which, it is thought, they meant barren cows. Columella, when talking of cattle, says, 'and, like the *tauræ*, which occupy 'the place of *fertile* cows, should be rejected †.' Varro likewise informs us, that 'the cow which is *barren* is 'called *taura*.'

Mr. Hunter gives an anatomical description of three free martins, the most perfect of which we shall transcribe.

'*Mr. Arbuthnot's Free Martin* §.

'The external parts were rather smaller than in the 'cow. The vagina passed on, as in the cow, to the open-'ing of the urethra, and then it began to contract into 'a small canal, which passed on to the division of the 'uterus into two horns; each horn passed along the 'edge of the broad ligament laterally towards the ovaria. 'At the termination of these horns were placed both the 'ovaria and the testicles; both were nearly of the same 'size, which was about as large as a small nutmeg. To 'the ovaria I could not find any Fallopian tube. To the 'testicles were vasa deferentia; but they were imperfect. 'The left one did not come near the testicle; the right 'one came close to it, but did not terminate in a body 'called the epididymis. They were both pervious, and 'opened into the vagina near the opening of the urethra. 'On the posterior surface of the bladder, or between the 'uterus and bladder, were the two bags called *vesiculæ* '*seminales* in the male, but much smaller than what they 'are in the bull: The ducts opened along with the vasa 'deferentia ‖.'

SECTION

* Hunter's Observations on the Animal Œconomy, p. 50. S. † Columella, lib. 6. cap. 22. S.

§ 'This animal was seven years old, had been often yoked with the oxen, at 'other times went with the cows and bull, but never showed any desires for either 'the one or the other.'

‖ Hunter's Observations on the Animal Œconomy, p. 52. S.

SECTION II.

Of the Sexes of Plants.

WHEN an hypothefis, or theory, has obtained a general reception among even the enlightened part of mankind, it is extremely difficult to eradicate the prejudice, either by arguments or by facts. There is not a notion more generally adopted, than that vegetables have the diftinction of fexes, and that the influence of what is called the male is indifpenfibly neceffary to the fecundation of the female, or feed-bearing plant: A notion which I have long confidered as a ftriking example of the danger of rafhly yielding affent to the alluring feductions of analogical reafoning *.

Every perfon who is acquainted with the fexual theory of vegetables, and with the arguments by which it is defended, muft acknowledge, that its principal fupport is derived from the many beautiful analogies which fubfift between plants and animals. Becaufe all animals were fuppofed to propagate by fexual embraces, and becaufe plants refembled animals in their growth, their nourifhment, their diffemination, and decay, it was therefore concluded, that all vegetables were either male, female, or hermaphrodite; and that fexual commerce was equally neceffary

* The fubftance of the following facts, and reafoning, was delivered, above twenty years ago, in the Botanic Garden at Edinburgh, in prefence of the late worthy and learned Dr. Hope, and his ftudents. Dr. Hope, in order to excite induftry and attention in his pupils, appointed annually four of their number to give a lecture, or difcourfe, upon fome botanical fubject, which he prefcribed to them. To me the Profeffor affigned the Sexes of Plants, with the liberty of oppofing the doctrine of Linnæus, and his own. Being at that time a very young man, and a ftrict believer in the fexual fyftem of plants, I willingly undertook the tafk, becaufe I thought I had the chance of fhowing fome little ingenuity in attempting to fhake a theory which I then imagined to be eftablifhed upon the firmeft bafis of fact and experiment. But, after perufing Linnæus's works, and many other books on the fubject, I was aftonifhed to find, that this theory was fupported neither by facts nor arguments, which could produce conviction even in the moft prejudiced minds. This difcourfe was afterwards publifhed in the firft edition of the Encyclopedia Britannica. S.

neceſſary for the fecundation of the vegetable as of the animal tribes.

This analogy was plauſible, and ſeemed to beſtow a ſplendid uniformity on the conduct of Nature. But experiment, the only teſt of natural truths, has totally annihilated this beautiful fabrick. The numberleſs ſpecies of vine-fretters, of polypi, of millepedes, and of infuſion-animalcules, multiply, without having recourſe to the common laws of generation. Here, then, the analogy ſtops; and, inſtead of bringing aid to the ſexualiſt, operates powerfully againſt his favourite hypotheſis. If many ſpecies of animals are deſtitute of all the endearments of love, what ſhould induce us to fancy that the oak or the muſhroom enjoy theſe diſtinguiſhed privileges?

The analogy, beſides, is frequently contradicted in the ordinary œconomy of vegetables. It is univerſally allowed, for example, that, even in oviparous animals, the eggs can only be impregnated while they are in a gelatinous or mere embryo ſtate. When farther advanced, their membranes, or ſhells, acquire a conſiſtence ſufficient to reſiſt the male influence. But, among the vegetable tribes, every circumſtance is reverſed. In moſt hermaphrodite plants, (I muſt ſpeak in the language of the ſyſtem), the ſeeds are not only not in a gelatinous ſtate, but have acquired conſiderable bulk and ſolidity, long before the pollen, or ſuppoſed fecundating duſt, is thrown out of its capſules.

The ſame remark is applicable to dioicous plants, or ſuch as are barren and ſeed-bearing in different individuals. What concluſion is here to be drawn? Analogy fails; and facts contradict the analogy. The pollen of moſt plants ſheds after the ſeeds of their reſpective ſpecies are far advanced in ſize and conſiſtence. If this pollen had the power of fecundating, it could ſeldom impregnate plants of its own ſpecies; becauſe, when it is diſcharged, the ſeeds are paſt the proper ſeaſon; but, by flying promiſcuouſly abroad, this pollen might impregnate different ſpecies which happened then to be in a fit condition for the reception of male influence. Conſider the conſequences of ſuch an arrangement. Is not this to make Nature

operate

operate againſt her own intentions? Nature intends that plants ſhould multiply and perpetuate their kinds; but the ſexual hypotheſis makes her take the moſt effectual meaſures to prevent that intention, and to introduce univerſal anarchy among the vegetable tribes. Were this theory true, the whole vegetable kingdom, in a few years, would be utterly confounded: Inſtead of a regular ſucceſſion of marked ſpecies, the earth would be covered with monſtrous productions, which no botaniſt could either recogniſe or unravel.

The propagation of plants by ſuckers, ſlips, and cuttings, is a curious fact in the hiſtory of vegetation. The ſtrawberry is commonly raiſed by ſlips taken from the old root, or by ſuckers ſent off from the plant. In either of theſe methods, the plants flouriſh, and produce fruit. Many bulbous and eye-rooted plants, and moſt ſhrubs and trees, may be propagated in the ſame manner. Where, it may be aſked, do theſe plants procure impregnation? That they grow, and produce fertile fruit, is undeniable; and yet, according to the ſexual hypotheſis, the pollen of the male is indiſpenſibly neceſſary to the ripening and fertilization of the fruit. By means of ſuckers, ſlips, cuttings, and layers, the whole globe might be ſpread over with vegetables, without the poſſibility of a ſingle impregnation.

Though the argument from analogy ſhould be inconcluſive, yet, ſay the ſexualiſts, we appeal to facts. I ſhall, therefore, give a ſhort view of the principal facts employed to ſupport the ſexual intercourſe of plants.

After what has been remarked, it will not be expected that I ſhould mention thoſe parts of Linnæus's reaſoning which are derived from analogy. In many inſtances, he has puſhed analogy ſo far beyond all decent limits, that it becomes truly ridiculous. For example, he gravely tells us, 'That the calix repreſents the marriage *bed*; the 'corolla the *curtains*; the filaments the *ſpermatic veſſels*; 'the antheræ the *teſtes*; the pollen the *male ſemen*; the 'ſtigma the extremity of the *female organ*; the ſtylus the

 '*vagina*;

'*vagina*; the germen the *ovarium*; the pericarpium the '*impregnated ovarium*; and the feeds the *eggs* *.'

The most plausible fact in favour of the sexual hypothesis is derived from the culture of the date-bearing palm-tree. Hasselquist †, and some other travellers, mention their having seen flowering branches of male trees fixed to the femals by Arabian gardeners, who alledged, that, unless this operation were performed, their dates would neither be good nor plentiful. This practice can boast of an antiquity long prior to the notion of sexes in plants. How it came to be introduced, it is of little importance to inquire. We know that the custom is still said to prevail: But we likewise know, that there is not an authentic fact which shows any connection between the *practice* and the *event*, though that be an essential ingredient in the controversy. The eastern nations are famous for introducing superstition into every part of their œconomy; and it is equally difficult to account for their manners as for their culture of palm-trees.

Mylius's letter to Dr. Watson, recorded in the Philosophical Transactions, is an attempt to remove this difficulty, and to show a necessary connection between the male and female palm. Mylius writes to his correspondent, 'That a female palm-tree grew many years in the 'garden belonging to the Royal Academy at Berlin, 'without producing any ripe or fertile fruit; that a male 'branch, with its flowers in full blow, was brought from 'Leipsic, about twenty German miles from Berlin, and suspended over the female tree. The result was, that the 'female yielded, the first year, 100 ripe dates. The same 'experiment being repeated the following year, 2000 'ripe fruit were produced.'

Not to call Mylius's veracity in question, the experiment is both inconclusive and defective. Berlin is not the climate of palm-trees. The tree, he informs us, bore flowers and fruit for thirty years before the trial was made; but the fruit, it is said, never came to maturity. Plants seldom produce ripe fruit in a climate not adapted to

* Sponsalia Plantarum, in Amœn. Acad. vol. 1. p. 103. S.

† Hasselquist's Travels, p. 112. 416. Kæmpfer. Amœn. p. 706. Tournefort Isag. p. 69. S.

to their nature, until they have grown there a long time. Mylius's palm-tree had carried unripe fruit for thirty years. According to the uſual courſe of exotic plants, therefore, it is natural to think, that, like the American aloe, the tree, during all this time, was making gradual advances toward perfection; that, when the male branch happened to be ſuſpended over the female, the plant had arrived at the higheſt degree of maturity it could ever acquire in the climate of Berlin; and, of courſe, that the accidental circumſtance of ſuſpending the male branch over it, at this critical period, might give riſe to the deception of attributing the ripening of the fruit to the preſence of the male branch. The production of 100 ripe fruit only the firſt year, and 2000 the ſecond, is a ſtrong corroboration of this account of the matter. At any rate, the experiment is exceedingly defective and unſatisfactory. To convince any man that the fertility of this tree was ſolely owing to ſome impregnating virtue communicated to it by the male, a branch ſhould have been ſuſpended over the female one year, omitted the next, and ſo on alternately for a ſucceſſion of ſeaſons, or, as the ſexualiſts would expreſs it, giving her a huſband one year, and denying her that gratification the next. After treating the female in this manner, if it had uniformly happened, that the fruit ripened every year the male branch was ſuſpended, and that none came to maturity when that operation was omitted, then there would have been ſome foundation for ſuppoſing a connection between the ripening of the fruit and the preſence of the male branch. But, as this neceſſary precaution was omitted, the experiment is incomplete, and the concluſion drawn from it precipitate and unphiloſophic.

In accounting for the fecundity of all the *dioicous** and *monœcious*† plants, the ſexualiſts have recourſe to the aid of the winds, and of inſects. They betake themſelves to this ſtrange refuge, in order to explain the manner in which female plants, when ſituated at a diſtance from males,

* Plants which have the male character in one individual, and the female in another. S.

† Plants which have both the male and female characters in the ſame individual. S.

males, are impregnated. Some of them, as Kalm, and others, are perfectly ſatisfied with this ſuppoſed ærial commerce of vegetables, even when the males are ten, fifteen, or twenty miles diſtant from the females! Here, it may be remarked, that the multiplication of ſpecies is one of the moſt important laws of Nature. All the laws of Nature are fixed, ſteady, and uniform, in their operation: None of their effects are abandoned to thoſe uncertainties which neceſſarily reſult from chance, or from any fortuitous train of circumſtances. But, is there any thing, in northern climates at leaſt, more deſultory and capricious than the direction and motion of the winds? Can we form a conception of any thing more caſual and uncertain than the wayward paths of inſects? The very ſuppoſition, therefore, that Nature has expoſed the fertility of a tenth part of the whole vegetable kingdom, and many of them, too, plants of the utmoſt importance to man, and other animals, to ſuch accidental cauſes, is repugnant to every idea of ſound philoſophy. Beſides, the reverſe has been proved by Dr. Alſton, Camerarius, and Tournefort. Theſe gentlemen reared female plants of the ſpinage and hemp in ſuch ſituations, and with ſuch ſcrupulous precautions, to prevent any ſuppoſed impregnation by means of the wind, or of inſects, that it is difficult to conceive the poſſibility of any communication between the males and females. Theſe females, however, produced fertile ſeeds in the greateſt abundance.

Since theſe experiments were made, it has been diſcovered, that male flowers are ſometimes found lurking on the female plants of the ſpinage and hemp: And this diſcovery the ſexualiſts think ſufficient to account for the ſucceſs of Dr. Alſton's experiments. But, inſtead of ſolving the difficulty, this circumſtance ſeems to involve it in ſtill deeper obſcurity: For, that the pollen iſſuing from the antheræ of a male flower or two ſhould riſe, fall, and turn round in every direction, ſo as to light preciſely on the ſtigmata of all the ſuperior, inferior, and circumjacent female flowers, appears to exceed the common powers of human faith. Beſides, this circumſtance would ſeem to indicate, that there is no ſteadineſs in what is called

called *vegetable ſexes*. We are even told, that trees, which had continued many years under the character of females, but, from ſome ſtrange metamorphoſis, had ſuddenly dropped their female forms, and aſſumed the more robuſt features peculiar to the male part of the creation!

It was hinted above, that all the dioicous, monœcious, as well as moſt of the hermaphrodite flowers, being impregnated by means of the wind, ſeemed not to accord with the rules of philoſophizing; we ſhall now examine that doctrine more cloſely.

The pollen is allowed to be too large to get admiſſion into the ſtigmata, though laid upon them with the greateſt dexterity. This difficulty the ſexualiſts imagine to be removed, when they tell us, that moiſture makes the pollen ſplit, and diſcharge a ſubtile aura, and that this aura impregnates the ſeeds. But, though the pollen ſhould explode by the application of moiſture, and diſcharge a ſubtile aura, this exploſion could never effect the purpoſes of impregnation: For, when the pollen was lying on the ſtigma, the aura muſt neceſſarily blow off, inſtead of being abſorbed by that part of the plant. Is not the ſuppoſition ſingular, and even contradictory, that a plant ſhould be impregnated by a ſubſtance forcibly blown away from the female?

This reaſoning proceeds upon the admiſſion, that the pollen is laid with dexterity upon the ſtigma. But it will receive additional force, when I defy all the naturaliſts in the univerſe to produce an inſtance of a ſingle grain of pollen being ever ſeen on any part of a female plant, even when at no great diſtance from a male, far leſs upon the ſtigmata of each ſeparate flower. Granting, however, the pollen to be carried off from the male by the wind, yet, as the ſuppoſed fecundating aura it contains is much lighter than air, and is diſcharged by the ſlighteſt moiſture, it can never fall down upon the diſtant females, but muſt riſe and diſſipate in the higher regions of the atmoſphere. It may alſo be diſcharged by the application of rain, or dews, before the pollen is carried off by the wind from the male flowers: And, if the winds blow in a direction contrary to the ſituation of the female plants for

a few critical hours, the females muſt be rendered barren, at leaſt for a ſeaſon.

It is an eſtabliſhed fact, that coleworts, turnips, &c. when growing in gardens, ſometimes produce new varieties. Theſe varieties the ſexualiſts uniformly hold up as inſtances of hybrids, or mongrels, from fortuitous commixtures of different males and females. This concluſion, however, ſeems to be precipitate. It is well known to nurſerymen and gardeners, that, from ſeeds of the ſame individual plants, varieties ſometimes appear. If theſe varieties chance to have any qualities ſuperior in value to the original plants, their ſeeds, ſhoots, or ſlips, are collected, and the new kind is propagated with diligence. That the beauty of flowers, and the magnitude and flavour of fruits are improveable by particular modes of culture, and even by unknown accidents, is an undeniable truth: That theſe improved qualities, in whatever manner procured, continue in the kind, unleſs allowed to degenerate by negligence, is not leſs true. But there is nothing ſo wonderful in theſe phenomena as to require the moſt unbounded ſtretches of fancy to account for them. Are not the beauty, ſtrength, and magnitude of animals, equally improveable by culture? Does not an ox, tranſported from the comparatively barren mountains of Scotland, to the rich paſtures of Yorkſhire, aſſume qualities very different from thoſe he originally poſſeſſed? Why, then, ſhould an inconſiderable change in the conſtitution of a colewort, or a turnip, excite ſurpriſe? Plants are liable to be diverſified by numberleſs accidents. Perpetually fixed to the ſame local ſituation, they muſt receive, indiſcriminately, ſuch nouriſhment as is tranſmitted to them by the earth and air. When different kinds happen to grow very near each other, and, as they have not the choice of rejecting ſuch food as is preſented to them, may not exudations from the one be abſorbed by the roots of the other? May not the matter which tranſpires ſo copiouſly from the leaves and flowers of one plant be conveyed to, and abſorbed by, thoſe of a different kind? And may not this foreign nouriſhment occaſionally introduce ſome changes in the colour, texture, or flavour, of the leaves, flowers,

flowers, or fruit? Nay, is it not reaſonable to ſuppoſe, that ſolutions of various mineral ſubſtances, the action of particular manures, and a thouſand other circumſtances, may often induce ſuch changes? Why, then, ſhould we have recourſe to unnatural and ſtrained analogies, when the phenomena may be ſolved upon the principles of ſound philoſophy?

The learned Dr. Hope, late Profeſſor of Botany in the Univerſity of Edinburgh, who was a ſtrenuous ſupporter of vegetable ſexes, thought he had almoſt eſtabliſhed the theory by the following experiment upon the lychnis dioica, of which two varieties are natives of Scotland, the one bearing white, and the other red, flowers. The Doctor, about twelve years ago, raiſed a white female and a red male under the ſame glaſs-bell, which was ſunk ſo far in the ſoil as to prevent all communication with other vegetables. The bell terminated in a tube, which, for the occaſional introduction of a little freſh air, was ſtuffed with moſs. The ſeeds of the white female were ſown next ſeaſon; and, inſtead of white, the plants produced red flowers, in conſequence, it was imagined, of the influence of the male upon the female. He likewiſe aſſerted, that the red kind, when left to Nature, never brought forth white flowers, nor the white kind red flowers.

Upon this experiment we have to remark, 1. That nothing is more dangerous, or more fallacious in philoſophy, than the aſſumption of general poſitions without an accurate inveſtigation. The Doctor advanced, for example, that the red and white lychnis, when in a natural ſtate, never change their colours. This poſition is neither capable of admiſſion nor denial; becauſe no experiment, nor inquiry, ſeems ever to have been made on the ſubject: Yet it is aſſumed as a premiſe to the concluſion, that the change of the white into a red lychnis was occaſioned by the influence of the red male upon the white female.

2. That hybrids, or mules, uniformly participate of both the ſpecies or varieties by which they are engendered. A jack-aſs and mare never produce a ſimple aſs or horſe, but a mule, or mixture of the two. It ſhould ſeem, however,

ever, that this red lychnis transfused its own individual qualities, without allowing a single particle of the female to appear. This is contrary to every analogy. If the change had originated from sexual commixture, the progeny ought not to have been completely red, but pied, or a mixture of red and white. To whatever cause, therefore, this change may be attributed, it can never be ascribed to any thing analogous to generation.

3. That colour is a delicate and fluctuating quality. It depends so much on light, air, health, and perhaps some unknown causes, that botanists, with great propriety, have rejected it as a specific character. Suspecting that causes of this nature might change the colour of the white lychnis under consideration, I examined the condition of some plants then subjected to the same trials in our Botanic Garden. The flowers both of the red and white lychnis were then in full blow under the bell, the glass of which was thick, and of a darker green than our common beer-bottles. The light, of course, transmitted to the plants was lurid and obscure. They were also deprived of a free circulation of air. Under these unnatural circumstances, the plants had a sickly aspect. The flowers of the red variety, instead of a vivid red, were almost perfectly white. Here we have nearly an equal change made upon the same plant, without the possibility of its being affected by the intercourse of sexes. If plants are thus deprived of proper light and air, it cannot be surprising to see changes produced in the colour of their immediate descendents. The contaminated air escaping from the plants themselves, and from the soil under the bell, may be sufficient to produce this effect. I formerly mentioned, that the colour, and other qualities of plants growing near each other, may be changed by absorbing the matter of transpiration and exudation. The argument is applicable with peculiar force to plants imprisoned so closely, and having so little access to fresh air. In this situation, they must, of necessity, feed upon each other. Confine a man and a woman for years in a small ill-aired cell, and observe their aspect, and that of their progeny. Their appearance will be very different from that of children pro-

duced

duced by healthy parents, and enjoying the benefits of the ſun's rays, and of the open air.

4. That, independently of all theſe arguments, the experiment is incomplete. Even on the ſuppoſition of the exiſtence of ſexes in plants, the concluſion drawn from it cannot be admitted. The ſame change, for inſtance, might have happened, if, inſtead of a white female and red male, a white female had been impriſoned with a red female. In this caſe there could be no commixture of ſexes; and yet, it is highly probable, that both would have ripened their ſeeds, and that theſe ſeeds would have produced plants differently coloured from the ſame varieties growing in a natural ſtate. Till theſe indiſpenſible parts of the experiment, therefore, be tried, nothing can be concluded in favour of the ſexual ſyſtem.

5. That flowers growing from the ſame root, fruits upon the ſame tree, or raiſed from ſeeds of the ſame individual plant, often vary in colour, ſize, figure, and texture. Theſe varieties are apparent to the moſt ſuperficial obſervers; but they can never, with any degree of propriety, be aſcribed to the influence of ſex. The cauſes of ſuch variations are rather to be looked for in the expoſure of the plants with regard to light and air, the nature of the ſoil, the mode of culture, accidental injuries from dews, from electrical fire, from the poiſon or wounds of inſects, and from the abſorption of mineral ſolutions. In a word, if we are to hope for an explanation of theſe, and other minute changes in the appearances of plants, recourſe muſt be had to chemical and philoſophical principles, and not to an hypothetical commerce of ſexes.

The diſcourſe was concluded with the following ſentiment:—But I aim not at complete refutation; for experiments are ſtill to be made. I only wiſh to render the ſexual commerce of plants ſuſpicious, that the minds of men may be freed from the fetters of a ſyſtem, which has, perhaps, too long received the general aſſent of Europe; and that the œconomy of the vegetable kingdom may again be open to impartial inveſtigation.

To remove the poſſibility of male influence being con-

veyed by means of the wind, or of insects, about ten or twelve years ago, I thought, if a female plant could ripen her seeds within doors during the winter, the experiment would infallibly determine the controversy. With this view, I confined a female lychnis, which is a native plant of this country, and gave her such a degree of heat as made her produce flowers three months before any male flowers of the same species were blown in Britain. The flowers and the young seed had every appearance of health and vigour. But the plant itself, as usually happens to vegetables when forced to grow in unnatural situations, was feeble, slender, and double the common length it acquires in the fields. I waited the event. My expectations, however, were disappointed; for the flowers dropped long before the seeds were ripened. The plant was kept three years in the same situation; but still the flowers dropped, and no ripe seeds were produced. As the health of plants, like that of animals, depends upon many circumstances, as exposure to the open air, to light, to the agitations of the wind, which to them answers the invigorating purpose of exercise, to nocturnal dews, to natural rains, instead of artificial waterings, &c. I resolved to place the female lychnis in a situation where she might enjoy all these advantages, and at the same time be removed from every suspicion of a connection with male influence. For this purpose, I applied to my learned and ingenious friend Dr. Daniel Rutherford, now Professor of Botany in the University of Edinburgh, who, at that time, had a small garden, or rather a little area, in the heart of the city, which was surrounded with houses of five and six stories high, and distant from any male lychnis about an English mile. Dr. Rutherford received this female lychnis into his garden. The first summer after her admission, being enfeebled by her former three years confinement, she dropped her flowers, without producing fertile seeds. During three or four succeeding years, however, she remained in the same situation; and she not only ripened her seeds, but these seeds vegetated, without the possibility of any male impregnation; for the Doctor, after the young plants were in a state of discrimination,

mination, uniformly extirpated all the males, and never could difcover the veftige of a fingle male upon the female plants. Her female progeny, however, continued to bear fertile feeds for feveral fucceffive generations. If, after this, and fome experiments formerly mentioned, any fexualift choofes to have recourfe to the wind, and to infects, he may enjoy his theory; but few men of penetration will join him in opinion.

But, if thefe facts and reafonings fhould not be fufficient to convince every believer in the fexual fyftem of plants that the hypothefis has no foundation in Nature, Spallanzani, a late ingenious Italian naturalift, has, by a number of experiments, removed the poffibility of any rational doubt on the fubject.

Spallanzani, in order to make a complete inveftigation of this fubject, performed a number of experiments on what are called *hermaphrodite*, *monœcious*, and *dioicous* plants.

Hermaphrodite plants comprehend all thofe which have ftamina and piftils, or the male and female organs, in the fame flowers. To difcover whether the pollen had any influence upon the fertility of the feeds, Spallanzani forced open the petals, or flower leaves, fome time before they began to expand. He then cut off all the ftamina, or male parts, before the fuppofed fœcundating duft was ripe, leaving the female part to its fate. The refult was, that, in many of the plants, the feeds did not ripen, or even acquire their full fize; in others, they grew to the natural fize; but, after being committed to the ground, they did not germinate. Above thirty years ago, a fimilar fet of experiments were made, in the Botanic Garden at Edinburgh, by the late Dr. Alfton, the then Profeffor of Botany. But, whether Dr. Alfton's experiments were performed with greater dexterity than thofe of Spallanzani, it is impoffible to determine. The event, however, was the reverfe; for Dr. Alfton's plants, which were treated in the fame manner with thofe of Spallanzani, not only ripened their feeds, but thefe feeds, when fown, were found to be as fertile as if no fuch operation had been performed. But no experiments of this kind can be made with any degree of certainty upon hermaphrodite plants;

plants; becauſe they are impracticable, without wounding and injuring the tender flowers. By forcing open the petals ſome days before they would naturally unfold, the interior parts of the flowers are prematurely expoſed to the action of the air, of dews, and of the ſun's rays. Beſides, no man can determine what changes the young ſeeds may undergo, what injury they may ſuffer, by an unnatural deprivation of the ſtamina. In every flower treated in this rough manner, an extravaſation of ſap muſt unavoidably be produced. If a pregnant animal is wounded, and in a part too ſo intimately connected with the fœtus, what reaſon have we to expect a fertile and well-proportioned offspring?

Spallanzani next proceeded to trials on the monœcious plants, or thoſe which bear both male and female flowers ſeparately on the ſame individual. In ſpring 1777, he ſowed two ſpecies of the pompion, which belong to this diviſion of plants, in a ſituation removed from every ſuſpicion of foreign connection by means of the wind or of inſects. 'In the beginning of June,' ſays he, 'two individuals, for I had ordered two only to be raiſed, were 'juſt beginning to put forth a few flower-buds towards the 'bottom of the ſtalk. At this early period, the male 'flowers may be eaſily diſtinguiſhed from the female. 'The former, alſo denominated *barren* by botaniſts, have 'a ſlender ſtalk; while the ſtalk of the latter, where it 'joins the calyx, forms a tumor, conſiſting of the immature fruit. I paid daily viſits to theſe two individuals, 'and very carefully watched the progreſs of both ſorts of 'flowers. That there might be no ſuſpicion of the pollen 'exerting any influence upon the females, the males were 'deſtroyed at their firſt appearance. As fruit, when a 'ſmall quantity only is left upon a plant, is ſooner ripe, 'and grows to a larger ſize, becauſe it receives a greater 'quantity of nutritious juice, I left on each of my two 'individuals two flowers only. The buds that made their 'appearance afterwards were taken away, along with the 'male flowers. Meanwhile, my four gourds grew rapidly. Finding that, towards the middle of September, 'they had attained the uſual full ſize, I gathered one, in

'order

'order to inſpect the internal parts. The fleſh was too 'ſoft, becauſe the fruit was not thoroughly ripe ; but, in 'colour, ſtructure, and taſte, it reſembled fruit produced 'by plants which had their male flowers.—The ſeeds 'were in great number, and, as well internally as ex- 'ternally, were perfectly formed.—At the end of the 'month, the other three gourds were quite ripe. I there- 'fore gathered them, and put the ſeeds of each into a ſe- 'parate box, that I might be able to examine them at 'pleaſure. The lobes filled the whole inſide of the ſeeds, 'and had all the characters of perfect maturity.

'Thus far,' continues our author, 'there is a perfect 'agreement with the obſervations made on the ſeeds of 'ſome hermaphrodite plants, which ſeemed, notwith- 'ſtanding they were deprived of the efficacy of the pollen, 'to have acquired the ſame degree of perfection as thoſe 'impregnated in the uſual manner. But, as they did not 'grow, however perfect they might be in appearance, be- 'cauſe they had not been vivified by the pollen, I ima- 'gined, that, for the ſame reaſon, the ſeeds of my three 'gourds would not grow. It was, however, proper to 'make the experiment. I therefore dried one hundred 'and fifty in the ſun, and afterwards planted them in 'three pots, fifty in each, taken from ſeparate gourds. 'But the lateneſs of the ſeaſon, it being the 10th of Oc- 'tober, the conſtant rain, and the coolneſs occaſioned by 'it, circumſtances unfavourable to vegetation, obliged me 'to place my pots in a ſtove, which, though it was not 'heated, was kept warm by a contiguous chimney. *The 'event did not by any means correſpond to my expectation.* 'I took it for *granted*, that *none* of the ſeeds would *germi- 'nate ;* and yet they *almoſt all came up* very well*.'

Here it is pleaſant to obſerve candour and fair experiment triumphing over deep prejudice. From the above, and many other paſſages, it is evident that Spallanzani was a keen ſexualiſt, and that he expected his experiments, inſtead of overthrowing, would confirm, his faith ; but, like a true philoſopher, he candidly, though with reluctance, unhinges his favourite opinion.

* Spallanzani's Diſſertations, vol. 2. p. 276, &c. S.

'I reserved the remainder of the seeds,' continues Spallanzani, 'for another experiment to be made the following spring. Before it can be asserted that fructification has been complete, it is necessary, according to the determination of botanists, not only that the seeds should grow, but that they should also be capable of bringing productive seeds, or, in other words, of perpetuating the species. That I might learn whether the seeds of my three gourds enjoyed this prerogative, I caused some of them to be planted in the same place in May 1778; and, when they were grown to some size, they were, as in the foregoing experiment, carefully stripped of all their male flowers, one female flower only being left on each individual. These flowers were furnished with small gourds, which grew ripe towards the beginning of autumn, and the seeds they produced grew just as well as the former*.'

With regard to dioicous plants, or those which produce male flowers on one individual and female flowers on another, they are by far the most unexceptionable subjects for determining the existence or non-existence of sexes in plants. Accordingly, Bonnet, Fourgeroux, and Spallanzani, &c. about the year 1770, placed female plants of this description in situations so strictly guarded against the possibility of fœcundating dust being conveyed to the females either by the air or by insects, that the supposition of male influence baffles all the powers of imagination. These females, however, uniformly produced ripe seeds; and these seeds were as prolific as if they had been surrounded with males.

From the facts and arguments above related, and many others which might be adduced, it appears, that this beautiful theory, derived from a mistaken analogy, has no foundation in Nature. I would not have dwelt so long on this subject, if I had not sincerely wished that the minds of men might be emancipated from the fetters of a system which has too long received the almost universal assent of the literary world; and that the œconomy of the

* Spallanzani's Dissertations, vol. 2. p. 278. S.

the vegetable kingdom may again be open to impartial inquiries.

CHAPTER X.

Of the Puberty of Animals.

THE puberty of animals commences at that period of their exiftence when Nature endows them with the the power of multiplying the fpecies. This period is as various as the different tribes of animals. In fome it arrives fooner, in others later; but, in every animal, it is accompanied with fome remarkable changes in conftitution and affections. From infancy to puberty there is a gradual increafe of fize; but, immediately after that period, in both fexes, the growth of the body makes a fudden fpring, and acquires redoubled ftrength and activity. The growth of animals, however, does not always ftop at the age of puberty. Men, quadrupeds, and fifhes, continue to grow for fome time after their capacity of multiplying. But moft birds and infects feem to acquire their full dimenfions before they arrive at the age of puberty.

Before puberty, the voice of a man, like that of a woman, is fhrill and feeble. But, after that period, it becomes rough and ftrong. This effect is produced by fome unaccountable and fudden change in the organs of fpeech, which is not confined to the human fpecies; for the voice of a horfe or a bull is deeper after than before puberty. In eunuchs no fuch alteration of voice is to be obferved; for their voice, though fhrill and piercing, can never produce a low or deep note. At this period, too, that diftinguifhing characteriftic of man, the beard, begins to appear, together with other external and internal changes, which it is unneceffary to relate. But eunuchs are totally deftitute

deſtitute of beards. Theſe two facts indicate a connection which merits the attention of philoſophers.

With regard to the female ſex, they are by no means exempted from conſtitutional changes when they arrive at the age of puberty. The alteration in the tone of their voice, if it does happen, is hardly perceptible. Neither are their faces deformed by a beard, which, according to our preſent ideas, would have a diſguſting effect. At this period, however, their mammæ ſwell, and a periodical evacuation takes place, which produces wonderful revolutions in their conſtitution and affections. In both ſexes, the mental changes are not leſs remarkable than the corporeal. The powers of the mind expand, the force of genius is felt, and very different objects ſolicit attention: Inſtead of puerile amuſements, ambition, a warm and unaffected friendſhip, a generoſity and unſuſpicious demeanour, both in words and actions, are the almoſt univerſal characteriſtics of this period of human life. I mention it with pleaſure, that, as far as my obſervation extends, in youth, unleſs they are corrupted by example, by neglect, or by other cauſes, all men are honeſt, friendly, generous, and humane. If this remark be true, Nature is fully exculpated. But, when a young man enters into the buſineſs of life, his candour and ingenuouſneſs ſoon meet with a ſhock. This is the painful reverſe. Inſtead of liberality and integrity of conduct, he has to encounter with ſelfiſhneſs, chicane, and too often with direct villainy. This unhappy diſcovery turns his thoughts into a different current, contracts the noble openneſs of his heart, renders him ſuſpicious and guarded, and, if he ſhall chance to retain his integrity, he is obliged to aſſume, at leaſt, the appearance of jealouſy and deceit. I by no means intend this to be the univerſal character of mankind; I only lament that it is too general.

In every race of mankind of which we have any knowledge, the females arrive ſooner at puberty than the males. But, the age of puberty differs in different countries. This difference ſeems to originate from two cauſes, the temperature of the climate, and the quality of the food. Children of citizens, and of opulent parents, who are fed with

with rich and nourifhing victuals, arrive fooner at this ftate. Children, on the contrary, brought up in the country, or whofe parents are poor, require two or three years longer; becaufe their food is not only coarfe, but too fparingly given. In the fouthern regions of Europe, and in large cities, the females arrive at puberty about the age of twelve, and the males about fourteen. But, in northern climates, and in the country, girls hardly come to maturity till they are fourteen, and boys not before fixteen. In the warmeft regions of Afia, Africa, and America, the age of puberty in females commences at ten, and fometimes at nine.

After puberty, the Count de Buffon remarks, 'marriage is the natural ftate of man. A man ought to have 'but one wife, and a woman but one hufband. This is 'the law of Nature; for the number of females is nearly 'equal to that of the males. Such laws as have been enacted in oppofition to this natural principle, have originated folely from tyranny and ignorance. Reafon, humanity, and juftice, revolt againft thofe odious feraglios, 'in which the liberty and the affections of many women 'are facrificed to the brutal paffion of a fingle man. Does 'this unnatural pre-emineace render thofe tyrants of the 'human race more happy? No! Surrounded with eunuchs, and with women who are ufelefs to themfelves 'and to other men, they are tormented with the conftant 'appearance of that accumulated load of mifery they have 'created.'

All animals, as well as thofe of the human fpecies, undergo, at the age of puberty, fimilar changes in the form of their bodies, and in the difpofitions of their minds. From mild, placid, and gentle, they become bold, reftlefs, and ungovernable. Their bodies are then, in ftrength and fymmetry, perfectly accommodated to the new fentiments which Nature, for wife purpofes, excites in their minds. In the deer kind, the horns of the males appear not till they are fit for multiplying the fpecies. At this period, the creft, the wattles, and the plumage of the male gallinaceous birds acquire additional beauty, and their courage and ftrength are greatly augmented. The

 pigeon,

pigeon, inſtead of being querulous, timid, and voracious, whenever the age of puberty arrives, feels emotions of a very different kind. Conſcious of the new vigour he has acquired, he aſſumes a bold and important air. He ſtruts about with a majeſtic pride, and immediately addreſſes, with all the gaiety of a lover, ſome favourite female, whom he ſolicits with the moſt aſſiduous gallantry and attention. After the coy female gives her aſſent, their after conduct exhibits ſuch a mutual and ardent affection, and ſuch a conſtant fidelity, as afford no inconſiderable pattern to the human ſpecies.

With regard to fiſhes, we are totally ignorant of the periods when the different tribes of them acquire the power of multiplying. From the element they inhabit, from the rapidity of their motions, and from their deſultory and wandering mode of living, we are equally ignorant of many other important parts of their œconomy and manners. This continues to be an ample field for future inveſtigation, and highly worthy the attention of naturaliſts.

The œconomy and manners of inſects are more open to inſpection. Thoſe of the winged tribes undergo many changes, both in figure and ſtructure, before they arrive at the age of puberty. They firſt eſcape from the eggs in the form of minute caterpillars. In this ſtate they are exceedingly voracious, and grow with rapidity to their full ſize; but they are deſtitute both of the power and of the organs neceſſary for the multiplication of the ſpecies. They are next transformed into chryſalids: In this ſtate, their bodies are covered with a kind of cruſt, or ſhell, from which the animals have again to eſcape, as from a ſecond egg. In this impriſoned condition, they remain during a longer or ſhorter period, according to the ſpecies, or to the ſeaſon of the year in which they are transformed. After their transformation into flies, they burſt this cruſt, or ſhell, and appear in the form of flies, furniſhed with wings, legs, feelers, &c. of all which they were deſtitute in their former ſtate. When transformed into flies, caterpillars have arrived at the age of puberty. They are now perfect animals, and endowed with the faculty of tranſmitting a numerous progeny to poſterity.

CHAP.

CHAPTER XI.

Of Love.

THE great intention of Nature, in endowing almoſt every animal with a ſexual attachment, is the multiplication and continuation of the reſpective ſpecies. But, with regard to man, and, in an inferior degree, to all pairing animals, love is the ſource of many other ſocial and important advantages. Love, or a ſtrong affection for a particular woman, is, to young men, perhaps, one of the greateſt incentives to virtue and propriety of conduct. In northern countries, it ſeldom riſes to that degree of frenzy, which, in warmer climates, not only engroſſes the whole attention, but often totally unhinges the powers of the mind. In northern regions, however, it occupies more gently the imagination, gives a chearfulneſs and alacrity to the buſineſs or ſtudies of life, and, if reciprocal, diffuſes over the mind and body a placid happineſs, and a tranquillity of diſpoſition, which greatly contribute to the health and vigour of both. A young man in love thinks that the eyes of his favourite continually behold him. Through this amiable medium he views all his actions, and even his thoughts. His affection and veneration are ſo great, that he is, in ſome meaſure, deterred from regarding any other woman, and, what is of more importance, from indulging any looſe or irregular appetite. The diſpoſitions and affections of the female are the ſame with thoſe of the male. Her attention is completely engroſſed; and ſhe never thinks or dreams of any man, but of him who is the object of her affection. A young man and a young woman in love exhibit the moſt innocent and the moſt amiable picture of human nature. Actuated by no intereſted motives, and regardleſs

lefs of future contingencies, they obey the fupreme command of Nature. How much is it to be lamented, that, from the cruel, but perhaps unavoidable, inftitutions and cuftoms of civil focieties, it is fo often not only prudent, but neceffary, to check, and even to overcome, this powerful law of Nature?

Many are the advantages that mankind derive from fociety and regular governments, and we fhould chearfully fubmit to thofe hardfhips and inconveniencies to which they give rife. But every man, however fubmiffive to the laws of his country, muft regret that neceffity which makes them oppofe any of the laws of Nature, and efpecially the almoft irrefiftible law of love.

In the prefent ftate of fociety, it muft be acknowledged, early marriages, among people in the ordinary and dependent ranks of life, are extremely hazardous. When both parties are induftrious and œconomical, fuch marriages are not only the moft natural, but are productive of the greateft happinefs and cordiality. But the reverfe is dreadful! Children, ftraitened circumftances, refentment of parents, whether real or affected, too often produce all the complicated miferies to which mankind, in their loweft ftate of degradation, can be fubjected. Among this order of men, therefore, it is of the higheft importance that the law of Nature fhould yield, for fome time at leaft, to the inftitutions of fociety, and to thofe prudential motives which parents learn from experience to be ingredients effential to the comfort and happinefs of life.

Men of fortune and of opulence have it in their power to obey the laws of Nature and of love; and fome examples, though few in number, occafionally happen, of rich men acting a difinterefted part in their matrimonial engagements. Inftead of following the dictates of Nature, many men of fortune and independence, difregarding the high privilege they enjoy, facrifice their tafte, their paffion, and often their happinefs during life, at the fhrine of Gold. To accomplifh this fordid end, they often embrace deformity, difeafe, ignorance, peevifhnefs, and every thing that is difgufting to human nature. Let fuch individuals fuffer their punifhment. But what are the

the conſequences to the public? Men of rank, in all nations and governments, not only regulate, in a great meaſure, the manners of their inferiors, but are the natural guardians of the ſtate. For theſe important purpoſes, their minds ſhould be noble, generous, and bold; and their bodies ſhould be ſtrong, maſculine, fit to encounter the fatigues of war, and to repel every hoſtile aſſault that may be made upon their country. But, when men of this deſcription, whatever be their motives, intermarry with weak, deformed, puny, or diſeaſed females, their progeny muſt of neceſſity degenerate. The ſtrength, beauty, and ſymmetry of their anceſtors are, perhaps, forever loſt. What is ſtill more to be regretted, debility of body is almoſt univerſally accompanied with weakneſs of mind. Thus, by the avarice, ambition, or inattention, of one individual, a noble and generous race is completely deſtroyed. By reverſing this conduct, it is true, the breed may again be mended; but, to repair a ſingle breach, many generations, endowed with prudence and circumſpection, will be requiſite. A ſucceſſive degeneration, however, is an infallible conſequence of imprudent or intereſted marriages of this kind. One puny race may for ſome time be ſucceeded by another, till at laſt their conſtitutions become ſo feeble that the animals loſe the faculty of multiplying their ſpecies. This gradual degeneration is one great cauſe of the total extinction of conſpicuous and noble families. That it ſhould be ſo, is a wiſe and beneficent inſtitution of Nature; for, if ſuch debilitated races were continued, a univerſal degenertion would ſoon take place, and mankind would be unable to perform the duties, or to undergo the labours, of life. Nature firſt chaſtiſes, and at laſt extirpates, all thoſe who act contrary to her eſtabliſhed laws.

Beſide the pleaſures reſulting from ſociety, and from mutual attachment in man, and in pairing animals, the natural love of offspring is a ſource of the moſt engaging endearments. The innocence and helpleſs condition of infants call forth our pity and protection. When a little farther advanced, their beauty, their ſmiles, and their ſprightlineſs, excite the moſt agreeable emotions. In their

their progreſs from infancy to manhood, we obſerve with pleaſure the unfolding of their mental powers. They imitate our actions long before they can expreſs their deſires, or their wants, by language. Their attempts in the acquiſition of language are extremely curious and amuſing. Their firſt ſyſtem of grammar conſiſts entirely of ſubſtantive nouns. It is long before they learn the uſe of adjectives or of copulatives, and ſtill longer before they employ the verb. Their ſpeeches are ſhort, aukward, and blundering; but they are animated, and uttered with aſtoniſhing force and vivacity of expreſſion in their eyes, and in the geſtures of their bodies. At this period of life, children are ſolely actuated by Nature and imitation. After they acquire words ſufficient for conveying the few ideas they poſſeſs, they begin to reaſon, or rather to employ the language of reaſoning; for, at this period of life, children, when they mean to give a reaſon why they ſhould have any indulgence or gratification, almoſt univerſally argue againſt themſelves, and employ a reaſon why their deſires ſhould not be granted. This ridiculous mode of reaſoning excites laughter, and affords pleaſure and amuſement to the parents. It likewiſe ſhows, that our firſt attempt toward reaſoning is principally, if not ſolely, the effect of imitation; for the reaſoning power, at this period, is not fully unfolded, becauſe many human inſtincts, or mental qualities, have not yet been called forth into action. But here I muſt ſtop. To do juſtice to this intereſting ſubject would require volumes.

The love of offspring, which, though not univerſal, is perhaps the ſtrongeſt and moſt active principle in human nature. It overcomes the ſenſe of pain, and ſometimes even the principle of ſelf-preſervation. A remarkable and a melancholy example of the ſtrength of parental affection was lately exhibited, and, for the honour of our ſpecies, deſerves to be recorded. In the beginning of January 1786, the Halſewell Eaſt-Indiaman, Captain Richard Pierce, was unfortunately wrecked on the coaſt of Dorſetſhire. Beſide ſeveral other ladies, Captain Pierce had two of his own daughters on board. When the ſhip was in the extremity of danger, ſome of the company,

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by ſwimming, and other feats of activity, got upon a rock. In this dreadful ſituation, Captain Pierce aſked Mr. Rogers, his third mate, if any plan could be deviſed for ſaving the ladies? Mr. Rogers replied, 'It is impoſſible! 'but you may ſave yourſelf.' Upon which the Captain, addreſſing himſelf to his daughters, and enfolding them in his arms, ſaid, 'Then, my dear children, we ſhall not 'part; we ſhall periſh together!' Mr. Rogers quitted the ſhip and reached the rock: An univerſal ſhriek of deſpair was heard, in which the voices of female diſtreſs and horror were lamentably diſtinguiſhable. In a few moments all was huſhed; the ſhip, with every perſon on board, had then gone to the bottom. Parents chearfully ſubmit to the hardeſt labour, and expoſe themſelves to the greateſt dangers, in order to procure nouriſhment to their young, or to protect them from injury.

A bitch, during the operation of diſſection, licked her young, whoſe preſence ſeemed to make her forget the moſt excruciating tortures; and, when they were removed, ſhe uttered the moſt dolorous cries. Certain ſpecies of ſpiders incloſe their eggs in a ſilken bag ſpun and wove by themſelves. This bag they fix to their back, and carry it along them wherever they go. They are extremely nimble in their motions. But, when the bag is forced from a ſpider of this kind, her natural agility forſakes her, and ſhe falls into a languid ſtate. When the bag is again preſented to her, ſhe inſtantly ſeizes it, and carries it off with rapidity. The young ſpiders no ſooner eſcape from the eggs than they dexterouſly arrange themſelves on the back of the mother, who continues for ſome time to carry them about with her, and to ſupply all their wants. Another ſpecies of ſpider attaches her bag of eggs to her belly. This ſpider is likewiſe very agile, and ſo ferocious and determined in the protection of her eggs, that ſhe has been known to ſuffer death rather than relinquiſh them. The deer ſpontaneouſly preſents herſelf to be chaced by the dogs, to prevent them from attacking her fawn. When the fox perceives that her young have been diſturbed in her abſence, ſhe carries them off, one after another, and conceals them in a new retreat. Waſps feed their young, when

when in the worm or caterpillar ſtate, in the ſame manner as pigeons and other birds that diſgorge. The pigeon, after ſwallowing grain, retains it for ſome time in her ſtomach, till it is ſoftened and macerated: She then diſgorges, and throws it into the mouths of her young. 'In 'the ſame manner,' ſays Reaumur, 'I have obſerved a 'female waſp ſwallow a large portion of an inſect: In a 'ſhort time afterwards, ſhe traverſed the different cells of 'her neſt, diſgorged the contents of her ſtomach, and 'diſtributed food in this half-digeſted form to her young 'worms *.'

All animals, man perhaps not excepted, acquire a double portion of force and courage after they bring forth. A cow, at leaſt in a domeſtic ſtate, is a placid and phlegmatic animal: But, whenever ſhe produces a calf, a wonderful change is exhibited: She inſtantly becomes vigilant, active, and even ferocious, in the defence of her young. A lioneſs deprived of her cubs preſents the moſt dreadful picture of anxiety, rage, and rapacity. Deſcending lower in the ſcale of animation, the ſame change is to be remarked. A domeſtic hen is a timid, indocile, and obſtinately-ſtupid creature. Though chaced, harraſſed, and even put in danger of her life, fifty times in a day, ſhe never learns to avoid a garden, or any particular place which ſhe is accuſtomed to frequent, or to which ſhe is led by her appetite for food. But, the moment her chickens are hatched, inſtead of her uſual timidity, ſhe becomes as bold as a lion. When ſhe thinks her young are in danger, ſhe briſtles up her feathers, aſſumes a fierceneſs in her eye, makes an alarming noiſe, and attacks, in the moſt furious manner, and without diſtinction, every animal that comes near her. By the ſuddenneſs of her onſets, ſhe often alarms men, and actually intimidates and beats off dogs and other animals that could devour her in an inſtant.

Though ſeveral of the inſect tribes diſcover a ſtrong attachment to their young, yet all thoſe which undergo transformations, and do not form ſocieties, muſt be completely ignorant of the exiſtence of their progeny; becauſe,

* Reaumur, tom. 11. pag. 230. 12mo edit. S.

caufe, in general, the parents die before the young are hatched. Nature, however, has endowed thofe fpecies with an inftinct which produces all the effects of parental affection: They uniformly depofit their eggs in fubftances which afford to the young, immediately after their efcape from the egg, a nourifhment adapted to their refpective conftitutions, and a comfortable and fafe protection from injury. Thus Nature, ever attentive to the continuation and happinefs of her productions, however feemingly infignificant in the fcale of being, often employs very different means to accomplifh the fame beneficent purpofes.

Nature has unqueftionably attached pleafure to all the neceffary functions of animals. But this pleafure cannot be confidered as the original caufe of any particular action; for the experiment muft be made before the animal can difcover whether the refult is to be agreeable or difagreeable. The truth is, that Nature has beftowed on the minds of all animated creatures a number of laws or inftincts perfectly accommodated to the fpecies, and which irrefiftibly compel them to perform certain actions. The effects of thefe laws we perceive: But the caufes, or the modes by which they operate on animal minds, are infcrutable. We may and muft admire, but we can never penetrate the myfteries of Nature.

Bonnet, and fome other naturalifts, imagine they are exhibiting the caufes of that ftrong and mutual attachment between parents and their offspring, when they tell us, that, in man, and quadrupeds, and birds, the mother is fond of her young, becaufe their natural actions give rife to agreeable fenfations; that, from the ftructure of the mammæ, a gentle, but pleafant, fenfation, is excited by the action of fucking; that the mother is often incommoded by too great a quantity of milk, and that fucking relieves her; that the young love their mother, becaufe fhe feeds, protects, and communicates to them a cherifhing warmth; that, among the feathered tribes, and particularly thofe which fit upon their young, by the gentle motions of the little ones, an agreeable fenfation is excited in the belly of the mother, which is then frequently deprived of feathers. All thefe fources of reciprocal pleafure

may be true: But ſtill they are only effects, and not original cauſes, of filial and parental affection; for that mutual attachment exiſts the moment after the young animals come into the world, and, of courſe, previous to all experience of titillation, of heat, of habit, or of any other circumſtances that may, perhaps, contribute to ſtrengthen or prolong the exertion of the primary cauſe, which muſt remain forever concealed from human penetration.

In moſt animals, except the human ſpecies, parental and filial affection ceaſe whenever the young are able to provide for themſelves. The pleaſures derived from ſucking, and from other circumſtances formerly mentioned, might for ſome time remain; but the young grow large, unwieldy, petulant, and enter into competitions for food, which not only contribute to alienate the affection of the parents, but even to excite reſentment and averſion. Theſe, however, are only ſecondary cauſes. The purpoſes of Nature are fulfilled. The ardour of affection, which was indiſpenſably neceſſary to the protection and rearing of the young, being now no longer uſeful, is ſo totally extinguiſhed, that neither the parents nor the offſpring are capable of recognizing one another. This temporary and amiable inſtinct is obliterated, and never revives till the fervours of love are again felt, and a new progeny appear.

Marriage, or pairing, though by no means an univerſal inſtitution of Nature, is not unfrequently exhibited in the animal creation. With regard to man, both male and female are inſtinctively impelled to make a ſelection. The force of this natural impulſe is ſtrongly felt by every young and uncorrupted individual. When not reſtrained by neceſſity, or other powerful motives, men and women would intermarry long before it would be prudent in civilized or artificial ſtates of ſociety. This univerſal, and almoſt irreſiſtible, impulſe of ſelection, is to me the ſtrongeſt argument in favour of monogamy, or the union of pairs, among the human ſpecies.

The ſame impulſe, or law of Nature, takes place among many other animals, as the partridge tribes, the ſwallow,

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the linnet, and, in general, all the ſmall birds. The aſſiduity, attention, mutual affection, laborious vigilance, and ſtedfaſt fidelity of pairing animals, are truly admirable, and, to ingenuous minds, afford the moſt exemplary admonitions to virtue and conjugal attachment.

Beſide this forcible impulſe of ſelection implanted by Nature in man, and in every other pairing animal, ſome other facts deſerve to be noticed. In all pairing animals, including, of courſe, the human race, the males and females produced are nearly equal. This is a plain indication that Nature deſtined theſe animals to pair, or to marry. Injuſtice, jealouſy, animoſity, and every animal calamity, would enſue, if this order of Nature were encroached upon in creatures who are endowed with the inſtinct of ſexual ſelection.

It is not incurious to remark, that human inſtitutions often contradict the laws of Nature. The dunghill-cock and hen, in a natural ſtate, pair. In a domeſtic ſtate, however, the cock is a jealous tyrant, and the hen a proſtitute. But, even in this unnatural ſociety, a ſelection is ſometimes to be obſerved. The ſame phenomenon is exhibited among mankind, when placed in certain ſituations. Like domeſtic poultry, the Turks, and ſome Aſiatic and African nations, influenced by an accurſed government, and by an execrable religion, rebel againſt the law of love, and of reciprocal attachment. In theſe countries, a rich man not only engroſſes, but impriſons and tortures, as many beautiful women as his fortune enables him to ſupport. Deſtitute of all thoſe endearments which ariſe from mental communication, from parental tenderneſs and affection, from mutual confidence and ſolace, he is, while young, perpetually tormented with jealous apprehenſions. As he advances in life, his jealouſy and his terror augment. Though his females are ſcrupulouſly guarded from every intruſion, by ſervile and mutilated wretches, his fears increaſe with his years and debility, till a premature and comfortleſs old age puts a period to his inſignificant and liſtleſs exiſtence.

In general, it is to be remarked, that all thoſe ſpecies of animals, whoſe offſpring require, for ſome time, the induſtry

induſtry and ſupport of both parents, are endowed with the inſtinct of ſelection, or of pairing. With regard to the feathered tribes, pairing is almoſt univerſal. A diſtinction, however, as to the duration and circumſtances of their pairing, is to be obſervéd. The young of all the ſmall birds, as well as of moſt of the larger kinds, continue for ſome weeks in a weak and helpleſs condition. The mother is not, like quadrupeds, provided with organs fitted to ſecrete milk; of courſe, ſhe is unable to nouriſh them out of her own body. She is therefore obliged to go abroad in queſt of food for them. But the progeny are ſo numerous, that all her induſtry, if not aſſiſted by the father, would be ineffectual for their ſupport and protection. In all birds whoſe young are in this condition, the males and females not only pair, but each of them is endowed with the ſtrongeſt parental affection. Both are equally anxious and induſtrious in procuring food for their mutual offspring. This parental care and attachment uniformly continues till the young are fledged, and have acquired ſufficient ſtrength to provide for themſelves. Eagles, and ſome other birds of prey, continue faithfully in pairs for years, and perhaps during life. Theſe facts afford a ſtrong argument in favour of marriage among mankind. No animal remains ſo long in the infant and helpleſs ſtate as the children of men; and no mother could, with her own induſtry, poſſibly ſuckle and procure nouriſhment for a numerous family. Here, as in the feathered tribes, the aſſiſtance of the father becomes indiſpenſable. On this ſubject, a curious inſtinct merits attention. The male of moſt birds not only ſelects a female, but, with great aſſiduity, brings food to her when ſitting on her eggs, and often relieves her, by ſitting on them himſelf.

There are other ſpecies of pairing birds, whoſe young, as ſoon as they are hatched, are capable of eating their food when preſented to them, and, of courſe, require leſs labour from the parents. In theſe ſpecies, accordingly, the male pays no attention to the progeny, becauſe it is unneceſſary; but the mother carefully leads them about to places where proper food is to be had, protects them from

from injuries, and communicates heat to them by covering them with her wings.

Quadrupeds, eſpecially thoſe which feed upon graſs, do not pair; becauſe, while the female gives ſuck to her young, ſhe herſelf is feeding. Beſide, the young of this tribe, very ſoon after birth, can eat graſs, and other vegetables. The Count de Buffon remarks, that the roe-deer, though they feed upon graſs, are to be excepted from this rule; for they pair, and have annually but one litter. Lions, tigers, wolves, and other rapacious quadrupeds, do not pair. The whole labour of procuring food is devolved upon the female, which often ſhortens her own life, as well as that of her offspring. In relation to man, this is a fortunate circumſtance; for, if beaſts of prey paired, a dangerous multiplication of thoſe deſtructive ſpecies would be the conſequence. But pairing is eſſentially neceſſary to birds of prey; becauſe, during the proceſs of incubation, the female would not have time ſufficient for procuring food; which, in theſe animals, requires both patience and addreſs. Some quadrupeds, particularly thoſe which lay up proviſions for the winter, as the beaver, pair. As ſoon as the young beavers are produced, the males abandon the ſtock of proviſions to the females, and go in queſt of food for themſelves. But they by no means relinquiſh their mates; but frequently return and viſit them while they are ſuckling their young.

If man, and ſome of the pairing animals, be excepted, the ſeaſons of love are limited to particular times of the year. Theſe ſeaſons, though various, are admirably adapted to the nature and œconomy of the different ſpecies. In all animals of this kind, the ſeaſons of love, and the times of female geſtation, are ſo contrived by Nature, that the offspring, when brought forth, are amply ſupplied with the particular ſpecies of food upon which they principally live. Though the times of geſtation vary conſiderably among ſuch quadrupeds as feed upon graſs, the reſpective females uniformly bring forth early in ſummer, when the graſs is tender and luxuriant. The mare comes in ſeaſon in ſummer, carries eleven months, and is delivered in the beginning of May. Sheep and goats come

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in ſeaſon in the end of October or beginning of November. They carry five months, and produce when the graſs begins to ſpring. It is worthy of obſervation, that, though the times of geſtation in the ſame ſpecies, and in all latitudes, never alter, yet the ſeaſons of love, and times of delivery, vary with the climate. In Italy, ſheep come in ſeaſon in the months of June or July. The females, as uſual, carry five months, and bring forth in November or December, the very period when graſs, in that climate, is in its beſt ſtate for paſture; for, in April, it is burnt up, and ſheep have nothing to browſe upon but ſhrubs. The rutting ſeaſon of the ſtag is in the end of September and beginning of October, and the female brings forth in May or the beginning of June. Theſe animals inhabit the higheſt mountains of Scotland, where the graſs, of courſe, does not begin to ſpring ſo early as in the lower parts of that country. Beavers come in ſeaſon about the end of autumn, and bring forth in January, when their ſtore-houſes are full of proviſions. The young of pairing birds are produced in the ſpring, when the weather begins to be comfortably warm, and their natural food abounds. In a word, the bringing forth, or hatching, of all animals, not excluding the inſect tribes, uniformly takes place at thoſe ſeaſons of the year when the nature of the weather, and the food peculiar to the ſpecies, are beſt adapted to the conſtitution of their offſpring. Caterpillars of every kind are never hatched till the various plants on which they feed, though they grow in different months, have put forth their leaves.

We ſhall conclude this ſubject, by giving a Table of the Relative Fecundity, &c. of Animals, which, in a ſhort compaſs, ſolves a number of queſtions with regard to the natural hiſtory of quadrupeds. It is taken from the eighth volume of the Tranſlation of Buffon, to whoſe authority moſt readers will be inclined to give great weight.

TABLE of the RELATIVE FECUNDITY of ANIMALS.

Names.	Age at which Males can engender, and Females produce. MALE. Years.	FEMALE. Years.	Times of gestation.	Number of young produced at a litter.	Age at which Males cease to engender, and Females to produce. MALE. Years.	FEMALE. Years.
Elephant -	30 -	30 -	2 years	1 in three or four years	lives 200	
Rhinoceros -	15 or 20 -	15 or 20 -	- -	1 - -	lives 70 or 80	
Hippopotamus	- -	- -	- -	1 -	- -	
Walrus -	- -	- -	9 months	1 -	- -	
Camel -	4 -	4 - -	1 year nearly	1 -	lives 40 or 50	
Dromedary -	4 -	4 - -	idem	1 - -	lives 40 or 50	
Horſe -	2 & 1-2 -	2 - -	11 months	1, ſometimes 2	at 25 or 30	at 18 or 20
Zebra -	2 -	2 - -	11 ditto	1, rarely 2	at 25 or 30	at 18 or 20
Aſs -	2 -	2 - -	11 ditto and more	1, rarely 2,	at 25 or 30	at 25 or 30
Buffalo -	3 -	3 - -	9 months	1 -	lives 15 or 18	
Ox -	2 -	1 & 1-2 -	9 ditto	1, rarely 2	at 9 -	at 9
Stag -	1 & 1-2 -	1 & 1-2 -	8 ditto and more	1, rarely 2	lives 30 or 35	
Rein-deer -	2 -	2 - -	8 months	1 -	lives 16	
Lama -	3 -	3 - -	- -	1, rarely 2	at 12 -	at 12
Man -	14 -	12 - -	9 months	1, ſometimes 2		
Large Apes -	3 -	3 - -	- -	1, ſometimes 2		
Mouflon -	1 & 1-2 -	1 - -	5 ditto	1, ſometimes 2 twice a year in hot climates	at 8 -	at 10 or 12
Saiga -	1 -	1 -	5 ditto	1, ſometimes 2	lives 15 or 20	
Roebuck -	1 & 1-2 -	2 -	5 ditto	1, 2, ſometimes 3	lives 12 or 15	
Chamois-Goat -	1 -	1 -	5 ditto	1, 2, rarely 3	lives 20	
Goat -	1 -	7 months -	5 ditto	1, 2, rarely 3, and never above 4	at 7 -	at 7

Names.	Age at which Males can engender, and Females produce. MALE. Years.	FEMALE. Years.	Times of gestation.	Number of young produced at a litter.	Age at which Males cease to engender, and Females to produce. MALE. Years.	FEMALE. Years.
Sheep -	1 -	1 -	5 months -	1, sometimes 2, twice a year in warm climates	at 8 -	at 10 or 12
Seal -	- -	- -	several months	2 o 3 -		
Bear -	2 -	2 -	ditto -	1, 2, 3, 4, and never above 5	lives 20 or 25	
Badger -	- -	- -	- -	3 or 4 .		
Lion -	2 -	2 -	- -	3 or 4 once a year	lives 20 or 25	
Leopard and Tiger	2 -	2 -	- -	4 or 5 once a year		
Wolf -	2 -	2 -	73 days or more	5, 6, to 9, once a year -	at 15 or 20	at 15 or 20
Dog in a natural state -	9 or 10 months	9 or 10 months	63 days -	3, 4, 5, 6 -	at 15 -	at 15
Isatis -	- -	- -	63 days -	6 and 7 -		
Fox -	1 -	1 -	In season in winter, and produces in April	3, 4, to 6 -	at 10 or 11	at 10 or 11
Jackal -	- -	- -	- -	2, 3, or 4 -		
Cat in a natural state	before 1 -	before 1 -	56 days -	4, 5, or 6	at 9 -	at 9
Martin -	1 -	1 -	56 days, it is said	3, 4, and 6	at 8 or 10 -	at 8 or 10
Pine-Weasel -	1 -	1 -	idem -	3, 4, and 6	at 8 or 10 -	at 8 or 10
Polecat -	1 -	1 -	idem -	3, 4, and 5	gener. during life	prod. during life
Weasel -	1st year -	1st year -	- -	3, 4, and 5	idem -	idem
Ermine -	idem -	idem -	- -	idem -	idem -	idem
Squirrel -	1 -	1 -	copulates in March, and produces in May	3 or 4 -	idem -	idem
Flying Squirrel	- -	- -	- -	3 or 4		

Names.	Age at which Males can engender, and Females produce. MALE. Years.	FEMALE. Years.	Times of geſtation.	Number of young produced at a litter.	Age at which Males ceaſe to engender, and Females to produce. MALE. Years.	FEMALE. Years.
Hedgehog	1	1	40 days	3, 4, and 5		
Dormice	1ſt year	1ſt year	-	3, 4, and 5	lives 6	
Muſk-Rats	-	-	-	4, 5, or 6		
Opoſſums	-	-	-	4, 5, 6, and 7		
Hogs	1 year or 9 months	1 year or 9 months	4 months	10, 12, 15, to 20, twice a year	at 15	at 15
Armadillos	-	-	-	4, ſeveral times a year		
Hare	1ſt year	1ſt year	30 or 31 days	2, 3, 4, ſeveral times a year	ives 7 or 8	
Rabbit	5 or 6 months	5 or 6 months	idem	4, 5, to 8, ſeveral times a year	idem	
Ferret	1ſt year	1ſt year	40 days	5, 6, to 9, twice a year	during life	
Rats	idem	idem	5 or 6 weeks	5 or 6, ſeveral times a year	idem	
Field Mice	idem	idem	1 month, or 5 weeks	9 or 10, ſeveral times a year		
Mouſe	idem	idem	idem	5 or 6, ſeveral times a year	idem	
Brown Rat	idem	idem	-	12 to 19 thrice a year	idem	
Guiney-Pig	5 or 6 weeks	5 or 6 weeks	3 weeks	eight times a year; 1ſt litter, 4 or 5; 2d, 5 or 6; and the others, 7, 8, to 11	lives 6 or 7, and produces during life	

CHAPTER XII.

Of the Transformation of Animals.

THE transformation of caterpillars, and of different kinds of worms, into winged inſects, has long excited the attention, as well as the admiration of mankind. But the truth is, that every animal, without exception, undergoes changes in ſtructure, mode of exiſtence, and external appearances. Mankind, from their embryo-ſtate, to their final diſſolution, aſſume many different forms. Some weeks after conception, the rudiments of a human being are to be perceived. As pregnancy advances, the approaches to the perfect figure become gradually more diſtinguiſhable, till the period of birth. While in the fœtus-ſtate, the head is diſproportionally large, when compared with the other parts of the body; nouriſhment is conveyed to it by very different channels; and reſpiration is not neceſſary, becauſe the circulation of the blood is not carried on in the ſame manner as after birth. Even after birth, the form, ſymmetry, and organs of the animal are by no means complete. The head continues for ſome time to be diſproportionally large; the hands and feet are not properly ſhaped; the legs are crooked; the hair on the head is ſhort and ſcanty; no teeth as yet appear; and there is not a veſtige of a beard. In a few months, however, the ſymmetry of all the parts is evidently improved, and the teeth begin to ſhoot. The growth of the whole body, as well as the ſtrength and beauty of its form, gradually advance to perfection till the ſixth or ſeventh year, when another change takes place. At this period, the firſt ſet of teeth are ſhed, and are replaced by new ones. From boyhood to puberty, the ſize of the body, and of its different members, in-

creaſe

creaſe. When the age of puberty arrives, ſeveral important changes are produced in the ſyſtem of both males and females. The beard now makes its appearance; the dimenſions of the body, in moſt individuals, are ſuddenly augmented; and both ſexes become capable of multiplying the ſpecies. From this period, to the age of twenty-five or thirty, the muſcles ſwell, their interſtices are filled with fat, the parts bear a proper proportion to each other, and man may now be conſidered as a perfect animal. In this ſtate of bodily perfection and vigour, he generally remains till he reaches his fiftieth year. Then a new but a gradual change begins to appear. From the fiftieth year to the age of ſeventy or eighty, the powers of the body decline in their ſtrength and activity. The muſcles loſe their ſpring and their force. The vigour of manhood is no longer felt, and the withered decrepitude of old age is ſucceeded by death, its unavoidable conſequence.

The mind of man undergoes changes as well as his body. The taſte, the appetites, and the diſpoſitions, are in perpetual fluctuation. How different is the taſte of a child from that of a man? Fond of gewgaws and of trifling amuſements, children frolic away their time without much thought or reflection. When advancing toward puberty, their diſpoſitions and deſires ſuffer a gradual mutation. New inſtincts are unfolded, and a ſenſe of propriety begins to be perceived. They deſpiſe their former occupations and amuſements; and different ſpecies of objects ſolicit and obtain their attention. Their powers of reflection are now conſiderably augmented; and both ſexes acquire a modeſty and a ſhyneſs with regard to each other. This aukward, but natural baſhfulneſs, by the intercourſe of ſociety, as well as by the impulſes of Nature, vaniſhes ſoon after puberty, when the ſtate of manhood and of gallantry commences. From this period to the age of twenty-five or thirty, men's minds aſſume a bold, enterpriſing, and active tone. They engage in the buſineſs of life, look forward to futurity, and have a deſire of marrying and of eſtabliſhing families. All the ſocial appetites are in vigour; ſolid and manly friendſhips are formed; and man goes on for ſome time

to enjoy every kind of happineſs which his nature is capable of affording. I wiſh the next change had no exiſtence. At fifty or ſixty, the mental powers, in general, like thoſe of the body, begin to decline, till feeble and tremulous old age arrives, and death cloſes the mutable ſcene of human life.

With regard to *quadrupeds*, both before and after birth, they undergo ſimilar, and many of them greater, changes of form than thoſe of the human ſpecies. Their mental powers, likewiſe, their diſpoſitions and manners, as well as the objects of their attention, vary according to the different ſtages of their exiſtence. Many of them come into the world blind, and continue for ſome time before they receive the ſenſe of ſeeing. How many changes are exhibited in the dog from birth till he becomes a perfect animal, till all his members are completely formed, and all his inſtincts are unfolded and improved by experience and education? The deer-kind acquire not their magnificent and beautiful horns before the age of puberty; and even theſe are annually caſt off and renewed. Similar changes take place in quadrupeds of every denomination; with examples of which every man's experience and recollection will readily ſupply him; and, therefore, it is unneceſſary to be more particular.

Neither are *birds*, in their progreſs from birth to maturity, exempted from changes. Like quadrupeds, many birds are blind for ſome time after they are hatched. In this condition, how different are their form and appearances from thoſe of the perfect animals! At firſt, they are covered with a kind of down inſtead of feathers. Even after the feathers ſhoot, they are often of a colour different from that which they acquire when full grown. The beautifully-variegated colours of the peacock's tail appear not till he arrives at his third year *. Birds that have creſts, or wattles, live a conſiderable time before they acquire theſe ornaments, or marks of diſtinction. All birds annually molt, or caſt their feathers, in the ſame manner as quadrupeds ſhed their hair, the new puſhing out the old.

Frogs,

* Linnæi Amœn. Acad. vol. 4. p. 368. S.

Frogs, and many other *amphibious* animals, undergo great changes in their form and ſtructure. When it firſt eſcapes from the egg, a frog appears in the form of a tadpole, an animal with a large roundiſh head, and a compreſſed or flat tail, but totally deſtitute of feet and legs. In this ſtate it remains a conſiderable time, when the two fore-feet begin to ſhoot, and have an exact reſemblance to the buds of trees. As their growth advances, the toes and legs are diſtinguiſhable. The ſame proceſs goes on with the hind-legs, only they are ſomewhat later in making their appearance. During the growth of the legs, the blood being drawn into different channels, the tail ſuffers a gradual mortification, till at laſt it totally vaniſhes, and the tadpole is metamorphoſed into a quadruped. Tadpoles never come out of the water; but, after their transformation into frogs, they become amphibious, and occaſionally frequent both land and water.

The *cruſtaceous* tribes, as lobſters, crabs, &c. beſide the different appearances they aſſume while growing to perfection, caſt their ſhells every year. When this change is about to happen, they retire into the crevices of rocks, or ſhelter themſelves below detached ſtones, with a view to conceal and defend their bodies from the rapacious attacks of other fiſhes. After the ſhells are caſt, the animals are exceedingly weak and defenceleſs. Inſtead of their natural defence of hard ſhells, and ſtrong claws, they are covered only with a thin membrane or ſkin. In this ſtate they become an eaſy prey to almoſt every fiſh that ſwims. The ſkin, however, gradually thickens and grows harder, till it acquires the uſual degree of firmneſs. By this time the animals have reſumed their former ſtrength and activity; they come out from their retirements, and go about in queſt of food.

Serpents, and many other *reptiles*, caſt their ſkins annually. The beauty and luſtre of their colours are then highly augmented. Before caſting, the old ſkins have a tarniſhed and withered appearance. The old ſkins, like the firſt ſet of teeth in children, are forced off by the growth of the new.

We

We come now to give ſome account of the transformations of *inſects*, which are both various and wonderful. All winged inſects, without exception, and many of thoſe which are deſtitute of wings, muſt paſs through ſeveral changes before the animals arrive at the perfection of their natures. The appearance, the ſtructure, and the organs of a caterpillar, of a chryſalis, and of a fly, are ſo different, that, to a perſon unacquainted with their transformations, an identical animal would be conſidered as three diſtinct ſpecies. Without the aid of experience, who could believe that a butterfly, adorned with four beautiful wings, furniſhed with a long ſpiral proboſcis or tongue, inſtead of a mouth, and with ſix legs, ſhould have proceeded from a diſguſting, hairy caterpillar, provided with jaws and teeth, and fourteen feet? Without experience, who could imagine that a long, white, ſmooth, ſoft worm, hid under the earth, ſhould be transformed into a black, cruſtaceous beetle, having wings covered with horny elytra, or caſes?

Upon this branch of the ſubject, we ſhall, *firſt*, give an example or two of the moſt common transformations of Inſects; and, *ſecondly*, deſcribe ſome of the more uncommon kinds.

Beſide their final metamorphoſis into flies, caterpillars undergo ſeveral intermediate changes. All caterpillars caſt or change their ſkins oftener or more ſeldom, according to the ſpecies. Malpighius informs us, that the ſilkworm, previous to its chryſalis ſtate, caſts its ſkin four times. The firſt ſkin is caſt on the 10th, 11th, or 12th day, according to the nature of the ſeaſon; the ſecond in five or ſix days after; the third in five or ſix days more; and the fourth and laſt in ſix or ſeven days after the third. This changing of ſkin is not only common to all caterpillars, but to every inſect whatever. Not one of them arrives at perfection without caſting its ſkin at leaſt once or twice. The ſkin, after it is caſt, preſerves ſo entirely the figure of the caterpillar in its head, teeth, legs, colour, hair, &c. that it is often miſtaken for the animal itſelf. A day or two before this change happens, caterpillars take no food: They loſe their former activity, attach themſelves

to

to a particular place, and bend their bodies in various directions, till at laſt they eſcape from the old ſkin, and leave it behind them. The inteſtinal canal of caterpillars is compoſed of two principal tubes, the one inſerted into the other. The external tube is compact and fleſhy; but the internal one is thin and tranſparent. Some days before caterpillars change into the chryſalis ſtate, they void, along with their excrement, the inner tube which lined their ſtomach and inteſtines. When about to paſs into the chryſalis ſtate, which is a ſtate of imbecility, caterpillars ſelect the moſt proper places and modes of concealing themſelves from their enemies. Some, as the ſilk-worm, and many others, ſpin ſilken webs or cods round their bodies, which completely diſguiſe the animal form. Others leave the plants upon which they formerly fed, and hide themſelves in little cells which they make in the earth. The rat-tailed worm abandons the water upon the approach of its metamorphoſis, retires under the earth, where it is changed into a chryſalis, and, after a certain time, burſts from its ſeemingly-inanimate condition, and appears in the form of a winged inſect. Thus the ſame animals paſs the firſt and longeſt period of their exiſtence in the water, another under the earth, and the third and laſt in the air. Some caterpillars, when about to change into a chryſalis ſtate, cover their bodies with a mixture of earth and of ſilk, and conceal themſelves in the looſe ſoil. Others incruſt themſelves with a ſilky or glutinous matter, which they puſh out from their mouths, without ſpinning it into threads. Others retire into the holes of walls or of decayed trees. Others ſuſpend themſelves to the twigs of trees, or to other elevated bodies, with their heads undermoſt. Some attach themſelves to walls, with their heads higher than their bodies, but in various inclinations; and others chooſe a horizontal poſition. Some fix themſelves by a gluten, and ſpin a rope round their middle to prevent them from falling. Thoſe which feed upon trees attach themſelves to the branches, inſtead of the leaves, which are leſs durable, and ſubject to a greater variety of accidents. The colours of the caterpillars give no idea of thoſe of the future flies.

In general, the figure of chryſalids approaches to that of a cone, eſpecially in their poſterior part. When under this form, the inſect ſeems to have neither legs nor wings. It is incapable either of walking or of crawling. It takes no nouriſhment, becauſe it has no organs ſuited to that purpoſe; yet, in ſome ſpecies, life is continued for ſeveral months before their laſt metamorphoſis takes place. In a word, it ſeems to be a lifeleſs maſs. But, upon a more attentive obſervation, it poſſeſſes the power of bending upwards and downwards the poſterior part of its body. The ſkin, or exterior covering, of thoſe which do not ſpin cods, ſeems to be of a cartilaginous nature. It is commonly ſmooth and ſhining. In ſome ſpecies, however, the ſkin of the chryſalis is more or leſs covered with hair, and other rugoſities. Though chryſalids differ both in figure and colour, their appearances are by no means ſo various as thoſe of the caterpillars from which they are produced. The colour of ſome chryſalids is that of pure gold, from which circumſtance the whole have received their denomination. For the ſame reaſon they are called *aureliæ* in Latin. Some are brown, others green; and, indeed, they are to be found of almoſt every colour and ſhade.

The life of winged inſects conſiſts of three principal periods, which preſent very different ſcenes to the ſtudent of Nature. In the firſt period, the inſect appears under the form of a *worm*, or *caterpillar*. Its body is long, cylindrical, and conſiſts of a ſucceſſion of rings, which are generally membranous, and encaſed within each other. By the aid of its rings, or of crotchets, or of ſeveral pairs of legs, it crawls about in queſt of food; and its movements are, in ſome ſpecies, remarkably quick. Its head is armed with teeth, or pincers, by which it eats the leaves of plants or other kinds of food. In this ſtate, it is abſolutely deprived of ſex, and, conſequently, of the power of multiplication. Its blood moves from the tail toward the head. It reſpires either by ſtigmata or ſmall apertures placed on each ſide of its body, or by one or ſeveral tubes ſituated on its poſterior part, which have the reſemblance of ſo many tails. In the ſecond period, the inſect appears

under

under the form of a nymph, or that of a chryfalis. When an infect, after throwing off the fkin of the caterpillar, exhibits all its external parts, only covered with foft and tranfparent membranes, it is called a *nymph*. But, when to thefe membranes is added a common and cruftaceous covering, it receives the name of a *chryfalis*. While in the ftate of a nymph, or that of a chryfalis, infects, in general, are totally inactive, and feem not to poffefs any powers of life. Sunk into a kind of deep fleep, they are little affected with external objects. They can make no ufe of their eyes, their mouth, or any of their members; for they are all imprifoned by coverings more or lefs ftrong. No cares occupy their attention. Deprived of the faculty of motion, they remain fixed in thofe fituations which they have chofen for their temporary abode, or where chance has placed them, till their final metamorphofis into flies. Some of them, however, are capable of changing place; but their movements are flow and painful. Their blood circulates, but in a contrary direction from what takes place in the caterpillar ftate; for it proceeds from the head toward the tail. Refpiration continues to go on, but the organs are differently fituated. In the caterpillar, the principal organs of refpiration were placed at the pofterior part of the body; but now thefe fame organs are to be found at the anterior part of the animal. In the third period, the infect has acquired that perfect organization which correfponds to the rank it is to hold in the fcale of animation. The bonds of the nymph, or of the chryfalis, are now burft afunder, and the infect commences a new mode of exiftence. All its members, formerly foft, inactive, and folded up in an envelope, are expanded, ftrengthened, and expofed to obfervation. Under the form of a worm, or caterpillar, it crawled; under thofe of a nymph, or chryfalis, its power of motion was almoft annihilated; under the laft form, it is furnifhed with fix fpringy legs, and two or four wings, with which it is enabled to fly through the air. Inftead of teeth, or pincers, with which it divided a grofs aliment, it has now a trunk, by which it extracts the refined juices of the moft delicate flowers. Inftead of a few fmooth eyes which it poffeffed

in the worm or caterpillar ſtate, the new inſect is furniſhed with both ſmooth and convex eyes, to the number of ſeveral thouſands.

The internal parts of the inſect have likewiſe undergone as many changes as the external. The texture, the proportions, and the number of the viſcera, are greatly altered. Some have acquired an additional degree of conſiſtence; others, on the contrary, are rendered finer and more delicate. Some receive a new form, and others are entirely annihilated. Laſtly, ſome organs in the perfect inſect, which ſeemed formerly to have no exiſtence, are unfolded, and become viſible. The moſt important of this laſt kind are the organs of generation. The caterpillar, the nymph, and the chryſalis, were of no ſex. But, after transformation, both ſexes are diſtinguiſhable, and the animals are capable of multiplying their ſpecies.

We ſhall now give ſome examples of transformations which deviate from the common mode.

Some inſects hold a middle rank between thoſe which preſerve their original figure during life, and thoſe that ſuffer transformations. Their exiſtence is divided into two periods only. They walk in the firſt, and fly in the ſecond. Thus their only metamorphoſis conſiſts of the addition of wings, the growth and expanſion of which are performed without any conſiderable alteration in the figure of their bodies.

There is not a law eſtabliſhed among organized bodies which ſeems to be ſo univerſal, as that all of them grow, or augment in ſize, after birth, till they arrive at maturity. If a hen were to bring forth an egg as large as her own body, and if this egg, when hatched, were to produce a bird of equal dimenſions with either of the parents, it would be conſidered as a miracle. But the *ſpider-fly*, ſo denominated from its figure, affords an example of a ſimilar prodigy. This fly actually lays an egg, from which a new fly is hatched that is as large and as perfect as its mother. This egg is roundiſh, is at firſt white, and afterwards aſſumes a ſhining black colour. Upon a more accurate examination, however, this production was found to be an egg only in appearance. When the envelope

velope is removed, inftead of a gelatinous fubftance, the new infect, furnifhed with all its members, is difcovered. But this difcovery does not render the fact the lefs wonderful. All winged infects undergo their different tranfformations after being expelled from the bodies of their mothers, and receive great augmentations of fize before their metamorphofis into the nymph or chryfalis ftate, after which their growth ftops. But the fpider-fly affords an inftance of an infect transformed in the belly of its mother, and which grows no more after it efcapes from its envelope. This fact is fully authenticated by Reaumur *, Bonnet †, and other naturalifts.

The worm from which the tipula or crane-fly is produced is perfectly fmooth. Immediately before its firft transformation it retires under ground. After this metamorphofis, the furface of the nymph is furnifhed with a number of prickles. By means of thefe prickles, the nymph, when about to be transformed into a fly, raifes itfelf in its hole till the cheft of the infect is above ground. The fly then burfts its prifon, mounts into the air, and leaves its former covering behind in the earth.

Many fpecies of flies depofit their eggs in the leaves and different parts of plants. Soon after the egg is inferted into the leaf, a fmall tubercle begins to appear, which gradually increafes in magnitude till the animal is hatched, and has paffed through its different transformations. Thefe tubercles are known by the name of *galls*, and are very different in their form, texture, colour, and fize. Galls of every kind, however, derive their origin from the ftings of infects, which generally belong to the clafs of flies. The female fly, by means of her fting, makes incifions in the leaves or branches of a tree, and in each incifion fhe lays an egg. This egg is at firft extremely minute; but it foon acquires a confiderable bulk, and the gall has arrived at its full fize before the worm is hatched. This gall feems to be analogous to the membranes which inveft a fœtus, and expand in all directions in proportion to its growth. That the eggs of oviparous animals

* Reaumur, vol. 12. p. 412, edit. 12mo. S.

† Oeuvres de Bonnet, vol. 4. p. 28. edit. 8vo. S.

animals grow while in the ovarium is univerſally known; but it is ſingular that the eggs of gall-flies ſhould grow after being ſeparated from the body of the mother. Theſe eggs muſt undoubtedly be furniſhed with external veſſels, or a kind of roots, by which they extract juices from the internal cavity of the gall. Malpighius aſcribes the origin of galls to a corroſive liquor introduced by the fly into the wound. But Reaumur, to account for the growth of a gall, thinks it unneceſſary to have recourſe to any ſuppoſed poiſonous fluids, and attributes it to the ſuperabundant nutricious juices derived to that particular part by the continual action of the abſorbent veſſels of the egg, joined to its heat, which may be compared to a little fire placed in the center of the tumour.

Whether theſe cauſes are ſufficient to explain the growth of galls, we ſhall ſubmit to the judgment of the reader. But, that the eggs depoſited by the flies augment in ſize; that worms proceed from them; that theſe worms are nouriſhed, and live a certain time impriſoned in the galls; that they are there transformed into nymphs or chryſalids; and, laſtly, that they are metamorphoſed into winged inſects, which, by gnawing an aperture through the gall, take their flight in the air; are known and inconteſtible facts, of the truth of which every man may eaſily ſatisfy himſelf. Examine the common oak-galls, or thoſe of any other tree; if any of them happen to have no aperture, cut them gently open, and you are certain to find an egg, a worm, a chryſalis, or a fly: But in ſuch as are perforated by a cylindrical hole, not a veſtige of an animal is diſcoverable. The galls which make an ingredient in the compoſition of ink are thick, and their texture is very ſtrong and compact: That the ſmall animals they contain ſhould be able to pierce through ſuch a rigid ſubſtance is truly wonderful.

In the general order of Nature among oviparous animals, each egg includes one embryo only. A ſingular ſpecies of eggs, however, diſcovered by the celebrated Mr. Folks, late Preſident of the Royal Society of London, muſt be excepted. He found great numbers of them in the mud of ſmall rivulets. In ſize they equalled the head of

of an ordinary pin. They were of a brown colour, and their ſurface was cruſtaceous, through which, by employing the microſcope, ſeveral living worms were diſtinctly perceptible. By dexterouſly breaking the ſhell, he diſlodged them; and he found with ſurpriſe, that eight or nine worms were contained in, and proceeded from, the ſame egg. They were all well formed, and moved about with great agility. Each of them was incloſed in an individual membranous covering, which was extremely thin and tranſparent. It were to be wiſhed that the transformations of theſe extraordinary animals had been traced.

Some caterpillars, when about to transform, make a belt paſs round their bodies. This belt is compoſed of an aſſemblage of ſilken threads ſpun by themſelves, the ends of which they paſte to the twigs of buſhes, or other places where they chooſe to attach their bodies. They likewiſe fix their hind legs in a tuft of ſilk. After tranſformation, the chryſalids remain fixed in the ſame manner as before their metamorphoſis. The belt is looſe, and allows the chryſalis to perform its ſlow and feeble movements.

The whole moth-kind, as well as the ſilk-worm, immediately before their transformation into the chryſalis ſtate, cover their bodies with a cod or clue of ſilk, though the nature of the ſilk, and their mode of ſpinning, are very different. The cods of the ſilk-worm are compoſed of pure ſilk. Their figure is generally oval, which neceſſarily reſults from that of the animal's body upon which they are moulded. When ſpinning, they twiſt their bodies into the form of an S. The cod is produced by numberleſs circumvolutions and zigzags of the ſame thread. The ſilk is ſpun by an inſtrument ſituated near the mouth of the inſect. The ſilky matter, before it is manufactured by the ſpinning inſtrument, appears under the form of a gum almoſt liquid, which is contained in two large reſervoirs contorted like the inteſtines of larger animals, and which terminate at the extremity by two parallel and ſlender conduits. Each conduit furniſhes matter for one thread. The ſpinning inſtrument, as is evident when viewed by the microſcope, unites the two threads

threads into one. Thus a thread of ſilk, which has the appearance of being ſingle, is in reality double, and ſpun with great dexterity. Some writers, who delight in the marvellous, aſcribe foreſight to the ſilk-worm in ſpinning its cod. The ſilk-worm, it muſt be acknowledged, acts as if it foreſaw the approaching event. But the truth is, that, when the animal has acquired its full growth, its reſervoirs of ſilk are completely filled. It then ſeems to be ſtrongly ſtimulated to evacuate this glutinous matter. Its different movements and attitudes, while diſcharging the ſilk, produce thoſe oval bundles which clothe and ornament vaſt numbers of the human ſpecies.

Another ſpecies of caterpillar conſtructs its cod in the form of a boat with the keel uppermoſt; but it conſiſts not entirely of pure ſilk. The animal, with its teeth, detaches ſmall triangular pieces of bark from a buſh or a tree. Theſe pieces of bark it paſtes upon its body by means of a glutinous or ſilky ſubſtance, and they conſtitute a principal part of its cod.

Another ſpecies works alſo in wood, though not with equal art as the former. Its cod is compoſed entirely of ſmall irregular fragments of dried wood. Theſe fragments the animal has the addreſs to unite together, and to form of them a kind of box which covers and defends its whole body. It accompliſhes this purpoſe by moiſtening, for ſome moments, the pieces of wood in its mouth, and then attaches them to each other by a glutinous ſubſtance. Of this mixture the caterpillar forms a cod, the ſolidity of which is nearly equal to that of wood.

The moſt ſolitary of all inſects are thoſe who live in the internal parts of fruits. Many of them undergo their metamorphoſis in the fruit itſelf, which affords them both nouriſhment and a ſafe retreat. They dig cavities in the fruit, which ſome of them either line with ſilk, or ſpin cods. Others leave the fruit, and retire to be transformed in the earth.

The metamorphoſis of inſects has been regarded as a ſudden operation, becauſe they often burſt their ſhell or ſilky covering quickly, and immediately appear furniſhed with wings. But, by more attentive obſervation, it has been diſcovered,

discovered that the transformation of caterpillars is a gradual process from the moment the animals are hatched till they arrive at a state of perfection. Why, it may be asked, do caterpillars so frequently cast their skins? The new skin, and other organs, were lodged under the old ones, as in so many tubes or cases, and the animal retires from these cases, because they have become too strait. The reality of these encasements has been demonstrated by a simple experiment. When about to moult or cast its skin, if the foremost legs of a caterpillar are cut off, the animal comes out of the old skin deprived of these legs. From this fact, Reaumur conjectured, that the chrysalis might be thus encased, and concealed under the last skin of the caterpillar. He discovered that the chrysalis, or rather the butterfly itself, was inclosed in the body of the caterpillar. The proboscis, the antennæ, the limbs, and the wings, of the fly are so nicely folded up, that they occupy a small space only under the two first rings of the caterpillar. In the first six limbs of the caterpillar are encased the six limbs of the butterfly. Even the eggs of the butterfly have been discovered in the caterpillar long before its transformation.

From these facts it appears, that the transformation of insects is only the throwing off external and temporary coverings, and not an alteration of the original form. Caterpillars may be considered as analogous to the fœtuses of men and of quadrupeds. They live and receive nourishment in envelopes till they acquire such a degree of perfection as enables them to support the situation to which they are ultimately destined by Nature.

One would not readily believe that the *excrements* of a butterfly should be capable of exciting consternation in the minds of the people. But this event has frequently happened in different places and nations. Among many other prodigies which have terrified nations, *showers of blood* have been enumerated by historians. These showers of blood were supposed to portend great and calamitous events, as wars, the destruction of cities, and the overthrow of empires. About the beginning of July, in the year 1608, one of these pretended showers of blood fell

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in the ſuburbs of Aix, and for ſeveral miles round. This ſuppoſed ſhower of blood, M. de Reaumur remarks, would probably have been tranſmitted to us as a great and a real prodigy, if Aix had not then been poſſeſſed of a philoſopher, who, amidſt other ſpecies of knowledge, did not neglect the operations and œconomy of inſects. This philoſopher was M. de Peireſc, whoſe life is written by Gaſſendi. This life contains a number of curious facts and obſervations. Among others, M. de Peireſc diſcovered the cauſe of the pretended ſhower of blood at Aix, which had created ſo general an alarm. About the beginning of July, the walls of a church-yard adjacent to the city, and particularly the walls of the ſmall villages in the neighbourhood, were obſerved to be ſpotted with large drops of a blood-coloured liquid. The people, as well as ſome theologians, conſidered thoſe drops as the operation of ſorcerers, or of the Devil himſelf. M. de Peireſc, about that time, had picked up a large and beautiful chryſalis, which he laid in a box. Immediately after its transformation into the butterfly ſtate, M. de Peireſc remarked, that it had left a drop of blood-coloured liquor on the bottom of the box, and that this drop, or ſtain, was as large as a French ſou. The red ſtains on the walls, on ſtones near the highways, and in the fields, were found to be perfectly ſimilar to that on the bottom of M. de Peireſc's box. He now no longer heſitated to pronounce, that all thoſe blood-coloured ſtains, wherever they appeared, proceeded from the ſame cauſe. The prodigious number of butterflies which he, at the ſame time, ſaw flying in the air, confirmed his original idea. He likewiſe obſerved, that the drops of the miraculous rain were never found in the middle of the city; that they appeared only in places bordering upon the country; and that they never fell upon the tops of houſes, or upon walls more elevated than the height to which butterflies generally riſe. What M. de Peireſc ſaw himſelf, he ſhowed to many perſons of knowledge, or of curioſity, and eſtabliſhed it as an inconteſtible fact, that the pretended drops of blood were, in reality, drops of a red liquor depoſited by butterflies.

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To the ſame cauſe M. de Peireſc attributes ſome other ſhowers of blood related by hiſtorians; and it is worthy of remark, that all of them are ſaid to have happened in the warm ſeaſons of the year, when butterflies are moſt numerous. Among others, Gregory of Tours mentions a ſhower of blood which fell, in the time of Childebert, in different parts of Paris, and upon a certain houſe in the territory of Senlis; and, about the end of the month of June, another likewiſe fell under the reign of King Robert.

M. de Reaumur remarks, that almoſt all the butterflies which proceeded from different ſpecies of hairy caterpillars in his poſſeſſion, voided at leaſt one, and often ſeveral large drops of excrement, which had the colour of blood. The hairy caterpillar that feeds upon the leaves of the elm-tree, after its transformation, emits drops, the colour of which is of a more deep red than that of blood; and, after being dried, their colour approaches to that of carmine. From another caterpillar of the elm, which is larger, and much more common than the former, proceeds a butterfly, that, immediately after its transformation, emits a great quantity of red excrement. This ſpecies of caterpillar, in particular years, is ſo numerous, that it lays bare the whole trees in certain diſtricts. Myriads of them are transformed into chryſalids about the end of May or beginning of June. When about to undergo their metamorphoſis, they often attach themſelves to the walls, and even enter into the country houſes.—If theſe butterflies were all brought forth at the ſame time, and flew in the ſame direction, their number would be ſufficient to form ſmall clouds, to cover the ſtones, &c. of particular diſtricts with blood-coloured ſpots, and to convince thoſe who wiſh to fright themſelves, and to ſee prodigies, that a ſhower of blood had fallen during the night. Some of thoſe hairy caterpillars which live in ſociety upon nettles, likewiſe emit an excrementitious matter of a red colour. A thouſand examples of the ſame kind might be enumerated. Hence the notion of miraculous or portentous ſhowers of blood ſhould be forever baniſhed from the minds of men.

I would not have ſaid ſo much upon this ſubject, if I had not conſidered it to be the duty of every man, when it is in his power, to remove popular prejudices, eſpecially when they have a direct tendency to terrify the minds of men, and to cheriſh ignorance and ſuperſtition.

We not only read of ſhowers, but, what ſeems to be more unaccountable, of fountains running occaſionally with blood inſtead of water. Sir David Dalrymple, one of the Senators of the College of Juſtice in Scotland, a gentleman not more diſtinguiſhed by his learning and deep reſearch, than by his ſcrupulous integrity and propriety of conduct, relates, in his Annals of Scotland *, upon the authority of Hoveden and Benedictus Abbas, that, in the year 1184, 'A fountain near Kilwinning †, 'in the ſhire of Air, ran blood for eight days and eight 'nights without intermiſſion. This portent had frequently 'appeared, but never for ſo long a ſpace. In the opinion 'of the people of the country, it prognoſticated the effu-'ſion of blood. Benedictus Abbas, and R. Hoveden, re-'late the ſtory of this portent with perfect credulity. Be-'nedictus Abbas improves a little upon his brother; for 'he is poſitive that the fountain flowed with *pure* blood.' If Kilwinning, like Aix, had poſſeſſed ſuch a philoſopher as Peireſc, the redneſs of the water, if ever it did appear, would have received a moſt ſatisfactory explanation.

Transformations are not peculiar to animals. All *organized bodies* paſs through ſucceſſive changes. Plants, of courſe, are not exempted from mutation. What an amazing difference between an acorn and a ſtately oak? The ſeeds of plants may be compared to the chryſalids of butterflies. The ſeed, like the chryſalis, contains, in miniature, all the parts of the future plant. Theſe parts require only time, and other circumſtances neceſſary to vegetation, for their complete evolution. How different are the ſeed-leaves from thoſe of the plume? Beſide the general changes ariſing from growth, plants undergo a number of metamorphoſes from other cauſes. In northern climates, if we except a few evergreens, trees, during winter, are entirely ſtripped of their leaves. Inſtead of the pleaſant

* Vol. 1. page 293. S.

† A Scottiſh village. S.

pleaſant emotions excited by the variety of figures, movements, colours, and fragrance of the leaves, flowers, and fruit, during the ſpring and ſummer, nothing is exhibited in winter but the bare ſtems and branches. In this ſtate, the trees of the foreſt have a lugubrious appearance, and remind us of death and of ſkeletons. Very different are the emotions we feel in the ſpring, when the buds begin to burſt, and the leaves to expand. When ſummer approaches, another beautiful change takes place. The flowers, with all their ſplendour of colours, and ſweetneſs of flavours, are then highly delightful to our ſenſes. After performing the office of cheriſhing and protecting the tender fruit for ſome time, the flowers drop off, and a new change is exhibited. When the flowers fall, the young fruit appear, and gradually grow to maturity, perpetually preſenting varieties in their magnitude, colour, odour, and flavour. When the fruit or ſeeds are fully ripe, they are gathered for the uſe of man, drop down upon the earth, or are devoured by birds and other animals. After this change happens, to which all the others were only preparatory, the leaves begin to ſhed, winter commences, and the ſame ſeries of metamorphoſes go on during the exiſtence of the plant.

The changes juſt now mentioned are annual, and are ultimately intended to ſupply men and other animals with food. But plants are ſubjected to changes of form from cauſes of a more accidental nature. Varieties or changes in the figure of plants are often produced by ſoil, by ſituation, by culture, and by climate.

A plant is compoſed of the bark, the liber, or inner circle, the wood, and the pith. The calyx, or cup, the corolla, or flower-leaves, the ſtamina, and piſtils, are only expanſions of the bark, the liber, the wood, and the pith. The petals of all flowers, in a natural ſtate, are ſingle. But, when tranſplanted into gardens, many of them, eſpecially thoſe which are furniſhed with numerous ſtamina, as the anemone, the poppy, the peony, the ranunculus, the daiſy, the marigold, the roſe, &c. double, or rather multiply their flower-leaves without end. This change from ſingle to double, or monſtrous flowers,

flowers, as they are called, is produced by too great a quantity of nutricious juices, which prevents the subſtance of the liber from condenſing into wood, and transforms the ſtamina into petals; and it not unfrequently happens, that, when theſe double-flowering plants are committed to a poor ſoil, they become drier, are reduced to their natural ſtate, and produce ſingle flowers only. Plants which inhabit the valleys, when tranſported to the tops of mountains, or other elevated ſituations, not only become dwarfiſh, but undergo ſuch changes in their general ſtructure and appearance, that they are often thought to belong to a different ſpecies, though they are, in reality, only varieties of the ſame. Similar changes are produced when Alpine or mountain plants are cultivated in the valleys.

From culture and climate, likewiſe, plants undergo many changes. But this ſubject is ſo generally known, that to enlarge upon it would be entirely ſuperfluous. We ſhall only remark, that the older botaniſts, when they perceived the ſame ſpecies of plants growing in a different ſoil, or in a different climate, aſſume ſuch different appearances, conſidered and enumerated them as diſtinct ſpecies. But the modern botaniſts, to prevent the unneceſſary multiplication of ſeparate beings, have endeavoured to reduce all thoſe varieties ariſing from fortuitous circumſtances to their original ſpecies.

From theſe facts, and many others which might be mentioned, it appears, that, in both the animal and vegetable kingdoms, forms are perpetually changing. The mineral kingdom is not leſs ſubject to metamorphoſis; but theſe belong not to our preſent ſubject. Though forms continually change, the quantity of matter is invariable. The ſame ſubſtances paſs ſucceſſively into the three kingdoms, and conſtitute, in their turn, a mineral, a plant, an inſect, a reptile, a fiſh, a bird, a quadruped, a man. In theſe transformations, organized bodies are the principal agents. They change or decompoſe every ſubſtance that either enters into them, or is expoſed to the action of their powers. Some they aſſimulate, by the proceſs of nutrition, into their own ſubſtance; others

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they evacuate in different forms; and theſe evacuations make ingredients in the compoſitions of other bodies, as thoſe of inſects, whoſe multiplication is prodigious, and affords a very great quantity of organized matter for the nouriſhment and ſupport of almoſt every animated being. Thus, from the apparently vileſt and moſt contemptible ſpecies of matter, the richeſt productions derive their origin. The moſt beautiful flowers, the moſt exquiſite fruits, and the moſt uſeful grain, all proceed from the boſom of corruption. The earth is continually beſtowing freſh gifts upon us; and her powers would ſoon be exhauſted, if what ſhe perpetually gives were not perpetually reſtored to her. It is a law of Nature, that all organized bodies ſhould be decompoſed, and gradually transformed into earth. While undergoing this ſpecies of diſſolution, their more volatile particles paſs into the air, and are diffuſed through the atmoſphere. Thus animals, at leaſt portions of them, are buried in the air, as well as in the earth, or in water. Theſe floating particles ſoon enter into the compoſition of new organized beings, who are themſelves deſtined to undergo the ſame revolutions. This circulation of organized matter has continued ſince the commencement of the world, and will proceed in the ſame courſe till its final deſtruction.

With regard to the intentions of Nature in changing forms, a complete inveſtigation of them exceeds the powers of human reſearch. One great intention, from the examples above enumerated, cannot eſcape obſervation. In the animal world, every ſucceſſive change is a new approach to the perfection of the individuals. Men, and the larger animals, ſome time after the age of puberty, remain ſtationary, and continue to multiply their ſpecies for periods proportioned to their reſpective ſpecies. When thoſe periods terminate, they gradually decay till their final diſſolution. The ſame obſervation is applicable to the inſect tribes, whoſe transformations ſtrike us with wonder. The caterpillar repeatedly moults or caſts off its ſkin. The butterfly exiſted originally in the body of the caterpillar; but the organs of the fly were too ſoft, and not ſufficiently unfolded. It remains unfit to encounter

encounter the open air, or to perform the functions of a perfect animal, till some time after its transformation into a chrysalis. It then bursts through its envelope, arrives at a state of perfection, multiplies its species, and dies. All the changes in the vegetable kingdom tend to the same point. In the process of growing, they are perpetually changing forms till they produce fruit, and then they decay. Some plants, like caterpillars, go through all their transformations, death not excepted, in one year. But others, like man and the larger animals, beside the common changes produced by growth and the evolution of different organs, continue for many years in a state of perfection before the periods of decay and of dissolution arrive. But these perennial plants undergo, every year, all the vicissitudes of the annuals. They every year increase in magnitude, send forth new leaves and branches, ripen and disseminate their seeds, and, during winter, remain in a torpid state, or suffer a temporary death. These annual changes in trees, &c. have some resemblance to those of animals which produce at certain stated seasons only.

The distribution of life to an immensity of successive individuals seems to be another intention of Nature in changing forms, and in the dissolution of her productions. Were the existence of individuals perpetual, or were it prolonged for ten times the periods now established, life should be denied to myriads of animated beings, who enjoy their present limited portion of happiness.

CHAPTER XIII.

Of the Habitations of Animals.

MANY animals, as well as thoſe of the human ſpecies, are endowed by Nature with an architectonic faculty. This faculty is beſtowed on them for a number of wiſe and uſeful purpoſes. It enables them to conſtruct proper habitations for concealing themſelves, for defending them againſt the attacks of their enemies, for ſheltering and cheriſhing their young, and for protecting them from the injuries of the weather.

All animals of the ſame ſpecies, when not reſtrained by accidental cauſes, uniformly build in the ſame ſtyle, and uſe the ſame materials. From this general rule man is to be excepted. Poſſeſſed of a ſuperior number of inſtincts, of which the reaſoning faculty is a reſult*, he can build in any ſtyle, and employ ſuch materials as his taſte, his fancy, or the purpoſes for which the fabrick is intended, ſhall direct him. A cottage or a palace are equally within the reach of his powers. In treating of this ſubject, we mean not to trace the progreſs of human architecture, which, in the earlier ſtages of ſociety, is extremely rude, but to confine ourſelves to that of the inferior tribes of animated beings.

With regard to *Quadrupeds*, many of them employ no kind of architecture, but live continually, and bring forth their young, in the open air. When not under the immediate protection of man, theſe ſpecies, in rough or ſtormy weather, ſhelter themſelves among trees or buſhes, retire under the coverture of projecting rocks, or the ſides of hills oppoſite to thoſe from which the wind proceeds. Beſide theſe arts of defence, to which the creatures are prompted

* See Chap. V. Of Inſtinct. S.

prompted by inſtinct and experience, Nature furniſhes them, during the winter months, with a double portion of long hair, which protects them from cold, and other aſſaults of the weather.

Of the quadrupeds that make or chooſe habitations for themſelves, ſome dig holes in the earth, ſome take refuge in the cavities of decayed trees, and in the clefts of rocks, and ſome actually conſtruct cabins, or houſes. But, the artifices they employ, the materials they uſe, and the ſituations they ſelect, are ſo various, and ſo numerous, that our plan neceſſarily limits us to a few of the more curious examples.

The Alpine marmot is a quadruped about ſixteen inches in length, and has a ſhort tail. In figure, the marmots have ſome reſemblance both to the rat and to the bear. When tamed, they eat every thing preſented to them, as fleſh, bread, fruit, roots, pot-herbs, inſects, &c. They delight in the regions of froſt and of ſnow, and are only to be found on the tops of the higheſt mountains. Theſe animals remain in a torpid ſtate during winter. About the end of September, or the beginning of October, they retire into their holes, and never come abroad again till the beginning of April. Their retreats are formed with much art and precaution. With their feet and claws, which are admirably adapted to the purpoſe, they dig the earth with amazing quickneſs, and throw it behind them. They do not make a ſimple hole, or a ſtraight or winding tube, but a kind of gallery in the form of a Y, each branch of which has an aperture, and both terminate in a capacious apartment, where ſeveral of the animals lodge together. As the whole operation is performed on the declivity of a mountain, this innermoſt apartment is alone horizontal. Both branches of the Y are inclined. One of the branches deſcends under the apartment, and follows the declivity of the mountain. This branch is a kind of aqueduct, and receives and carries off the excrements of the animals; and the other, which riſes above the principal apartment, is uſed for coming in and going out. The place of their abode is well lined with moſs and hay, of which they lay up great ſtore during the ſummer. They

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are ſocial animals. Several of them live together, and work in common when forming their habitations. Thither they retire during rain, or upon the approach of danger. One of them ſtands centinel upon a rock, while the others gambol upon the graſs, or are employed in cutting it, in order to make hay. If the centinel perceives a man, an eagle, a dog, or other dangerous animal, he alarms his companions by a loud whiſtle, and is himſelf the laſt that enters the hole. As they continue torpid during winter, and, as if they foreſaw that they would then have no occaſion for victuals, they lay up no proviſions in their apartments. But, when they feel the firſt approaches of the ſleeping ſeaſon, they ſhut up both paſſages to their habitation; and this operation they perform with ſuch labour and ſolidity, that it is more eaſy to dig the earth any where elſe than in ſuch parts as they have thus fortified. At this time they are very fat, weighing ſometimes twenty pounds. They continue to be plump for three months; but afterwards they gradually decline, and, at the end of winter, they are extremely emaciated. When ſeized in their retreats, they appear rolled up in the form of a ball, and covered with hay. In this ſtate, they are ſo torpid that they may be killed without ſeeming to feel pain. The hunters ſelect the fatteſt for eating, and keep the young ones for taming. Like the dormice, and all the other animals which ſleep during winter, the marmots are revived by a gradual and gentle heat: And it is remarkable, that thoſe which are fed in houſes, and kept warm, never become torpid, but are equally active and lively during the whole year.

We ſhall now give a ſhort account of the operations and architecture of the *beaver*. This amphibious quadruped is about three feet in length, and its tail, which is of an oval figure, and covered with ſcales, is eleven inches long. He uſes his tail as a rudder to direct his courſe in the water. In places much frequented by man, the beavers neither aſſociate nor build habitations. But, in the northern regions of both Continents, they aſſemble in the month of June or July, for the purpoſes of uniting into ſociety and of building a city. From all

quarters they arrive in numbers, and ſoon form a troop of two or three hundred. The operations and architecture of the beavers are ſo well deſcribed by the Count de Buffon, that we ſhall lay it before our readers nearly in his own words. The place of rendezvous, he remarks, is generally the ſituation fixed upon for their eſtabliſhment, and it is always on the banks of waters. If the waters be flat, and ſeldom riſe above their ordinary level, as in lakes, the beavers make no bank or dam. But in rivers or brooks, where the water is ſubject to riſings and fallings, they build a bank, which traverſes the river from one ſide to the other, like a ſluice, and is often from 80 to 100 feet long, by 10 or 12 broad at the baſe. This pile, for animals of ſo ſmall a ſize, appears to be enormous, and preſuppoſes an incredible labour *. But the ſolidity with which the work is conſtructed is ſtill more aſtoniſhing than its magnitude. The part of the river where they erect this bank is generally ſhallow. If they find on the margin a large tree, which can be made to fall into the river, they begin, by cutting it down, to form the principal baſis of their work. This tree is often thicker than a man's body. By gnawing it at the bottom with their four cutting teeth, they in a ſhort time accompliſh their purpoſe, and always make the tree fall acroſs the river. They next cut the branches from the trunk to make it lie level. Theſe operations are performed by the joint induſtry of the whole community. Some of them, at the ſame time, traverſe the banks of the river, and cut down ſmaller trees, from the ſize of a man's leg to that of his thigh. Theſe they cut to a certain length, dreſs them into ſtakes, and firſt drag them by land to the margin of the river, and then by water to the place where the building is carrying on. Theſe piles they ſink down, and interweave the branches with the larger ſtakes. In performing this operation many difficulties are to be ſurmounted. In order to dreſs theſe ſtakes, and to put them in a ſituation nearly perpendicular, ſome of the beavers muſt elevate, with their teeth, the thick ends againſt the margin of the river, or againſt the croſs tree, while others

* The largeſt beavers weigh only 50 or 60 pounds. S.

others plunge to the bottom, and dig holes with their fore-feet to receive the points, that they may ſtand on end. When ſome are labouring in this manner, others bring earth, which they plaſh with their feet, and beat firm with their tails. They carry the earth in their mouths, and with their fore-feet. They tranſport earth in ſuch quantities, that they fill with it all the intervals between the piles. Theſe piles conſiſt of ſeveral rows of ſtakes, of equal height, all placed oppoſite to each other, and extend from one bank of the river to the other. The ſtakes facing the under part of the river are placed perpendicularly; but thoſe which are oppoſed to the ſtream ſlope upward to ſuſtain the preſſure of the water; ſo that the bank, which is ten or twelve feet wide at the baſe, is reduced to two or three at the top. Near the top, or thinneſt part of the bank, the beavers make two or three ſloping holes, to allow the ſurface-water to eſcape. Theſe they enlarge or contract in proportion as the river riſes or falls; and, when any breaches are made in the bank by ſudden or violent inundations, they know how to repair them when the water ſubſides.

Hitherto all theſe operations were performed by the united force and dexterity of the whole community. They now ſeparate into ſmaller ſocieties, who build cabins or houſes. Theſe cabins are conſtructed upon piles near the margin of the river or pond, and have two openings, one for the animals going to the land, and the other for throwing themſelves into the water. The form of theſe edifices is either round or oval, and they vary in ſize from four or five to eight or ten feet in diameter. Some of them conſiſt of three or four ſtories. Their walls are about two feet thick; and are raiſed perpendicularly upon planks, or plain ſtakes, which ſerve both for foundations and floors to their houſes. When they conſiſt of but one ſtory, they riſe perpendicularly a few feet only, afterwards aſſume a curved form, and terminate in a dome or vault, which anſwers the purpoſe of a roof. They are built with amazing ſolidity, and neatly plaſtered with a kind of ſtucco both within and without. In the application of this mortar the tails of the beavers ſerve

ſerve for trowels, and their feet for plaſhing. Their houſes are impenetrable to rain, and reſiſt the moſt impetuous winds. In their conſtruction, they employ different materials, as wood, ſtone, and a kind of ſandy earth, which is not liable to be diſſolved in water. The wood they uſe is generally of the light and tender kinds, as alders, poplars, and willows, which commonly grow on the banks of rivers, and are more eaſily barked, cut, and tranſported, than the heavier and more ſolid ſpecies of timber. They always begin the operation of cutting trees at a foot or a foot and a half above the ground: They labour in a ſitting poſture; and, beſide the convenience of this poſture, they enjoy the pleaſure of gnawing perpetually the bark and wood, which are their favourite food. Of theſe proviſions they lay up ample ſtores in their cabins to ſupport them during the winter. Each cabin has its own magazine, which is proportioned to the number of its inhabitants, who have all a common right to the ſtore, and never pillage their neighbours. Some villages are compoſed of twenty or twenty-five cabins. But theſe large eſtabliſhments are not frequent; and the common republics ſeldom exceed ten or twelve families, of which each have their own quarter of the village, their own magazine, and their ſeparate habitation. The ſmalleſt cabins contain two, four, or ſix, and the largeſt eighteen, twenty, and ſometimes thirty beavers. As to males and females, they are almoſt always equally paired. Upon a moderate computation, therefore, the ſociety is often compoſed of 150 or 200, who all, at firſt, labour jointly in raiſing the great public building, and afterwards, in ſelect tribes or companies, in making particular habitations. In this ſociety, however numerous, an univerſal peace is maintained. Their union is cemented by common labours; and it is perpetuated by mutual conveniency, and the abundance of proviſions which they amaſs and conſume together. A ſimple taſte, moderate appetites, and an averſion to blood and carnage, render them deſtitute of the ideas of rapine and of war. Friends to each other, if they have any foreign enemies they know how to avoid them. When danger

danger approaches, they advertiſe one another, by ſtriking their broad tail on the ſurface of the water, the noiſe of which is heard at a great diſtance, and reſounds through all the vaults of their habitations. Each individual, upon theſe occaſions, conſults his own ſafety; ſome plunge into the water; others conceal themſelves within their walls, which can be penetrated only by the fire of heaven, or the ſteel of man, and which no animal will attempt either to open or to overturn. Theſe retreats are not only ſafe, but neat and commodious. The floors are ſpread over with verdure: The branches of the box and of the fir ſerve them for carpets, upon which they permit not the ſmalleſt dirtineſs. The window that faces the water anſwers for a balcony to receive the freſh air, and for the purpoſe of bathing. During the greater part of the day, the beavers ſit on end, with their head and the anterior parts of their body elevated, and their poſterior parts ſunk in the water. The aperture of this window is ſufficiently raiſed to prevent its being ſtopped up with the ice, which, in the beaver climates, is often two or three feet thick. When this accident happens, they ſlope the ſole of the window, cut obliquely the ſtakes which ſupport it, and thus open a communication with the unfrozen water. They often ſwim a long way under the ice. The continual habit of keeping their tail and poſterior parts of their body in the water, appears to have changed the nature of their fleſh; for that of their anterior parts, as far as the reins, has the taſte and conſiſtence of the fleſh of land-animals; but that of the tail and poſterior parts has the odour and all the other qualities of fiſh. The tail, which is a foot long, an inch thick, and five or ſix inches broad, is a genuine portion of a fiſh attached to the body of a quadruped: It is wholly covered with ſcales, and below the ſcales with a ſkin perfectly ſimilar to that of large fiſhes. In September, the beavers collect their proviſions of bark and of wood. Till the end of winter, they remain in their cabins, enjoy the fruits of their labours, and taſte the ſweets of domeſtic happineſs. This is their time of repoſe, and their ſeaſon of love. Knowing and loving one another,

each

each couple unite, not by chance, but by taſte and a real ſelection. The females bring forth in the end of winter, and generally produce two or three at a time. About this period they are left by the males, who retire to the country to enjoy the pleaſures and the fruits of the ſpring. They return occaſionally, however, to their cabins; but dwell there no more. The mothers continue in the cabins, and are occupied in nurſing, protecting, and rearing their young, which in a few weeks are in a condition to follow their dams. The beavers aſſemble not again till autumn, unleſs their banks or cabins be injured by inundations; for, when accidents of this kind happen, they ſuddenly collect their forces, and repair the breaches that have been made.

This account of the ſociety and operations of beavers, however marvellous it may appear, has been eſtabliſhed and confirmed by ſo many credible eye-witneſſes, that it is impoſſible to doubt of its reality.

The habitation where *moles* depoſit their young merits a particular deſcription; becauſe it is conſtructed with peculiar intelligence, and becauſe the mole is an animal with which we are well acquainted. They begin by raiſing the earth, and forming a pretty high arch. They leave partitions, or a kind of pillars, at certain diſtances, beat and preſs the earth, interweave it with the roots of plants, and render it ſo hard and ſolid, that the water cannot penetrate the vault, on account of its convexity and firmneſs. They then elevate a little hillock under the principal arch; upon the latter they lay herbs and leaves for a bed to their young. In this ſituation they are above the level of the ground, and, of courſe, beyond the reach of ordinary inundations. They are, at the ſame time, defended from the rains by the large vault that covers the internal one, upon the convexity of which laſt they reſt along with their young. This internal hillock is pierced on all ſides with ſloping holes, which deſcend ſtill lower, and ſerve as ſubterraneous paſſages for the mother to go in queſt of food for herſelf and her offspring. Theſe by-paths are beaten and firm, extend about twelve or fifteen paces, and iſſue from the principal manſion like rays from a center.

a center. Under the ſuperior vault we likewiſe find remains of the roots of the meadow ſaffron, which ſeem to be the firſt food given to the young. From this deſcription it appears, that the mole never comes abroad but at conſiderable diſtances from her habitation. Moles, like the beavers, pair; and ſo lively and reciprocal an attachment ſubſiſts between them, that they ſeem to diſreliſh all other ſociety. In their dark abodes they enjoy the placid habits of repoſe and of ſolitude, the art of ſecuring themſelves from injury, of almoſt inſtantaneouſly making an aſylum or habitation, and of procuring a plentiful ſubſiſtence without the neceſſity of going abroad. They ſhut up the entrance of their retreats, and ſeldom leave them, unleſs compelled by the admiſſion of water, or when their manſions are demoliſhed by art.

The nidification of *Birds* has at all times deſervedly called forth the admiration of mankind. In general, the neſts of birds are built with an art ſo exquiſite, that an exact imitation of them exceeds all the powers of human ſkill and induſtry. Their ſtyle of architecture, the materials they employ, and the ſituations they ſelect, are as various as the different ſpecies. Individuals of the ſame ſpecies, whatever region of the globe they inhabit, collect the ſame materials, arrange and conſtruct them in the ſame form, and make choice of ſimilar ſituations for erecting their temporary habitations; for the neſts of birds, thoſe of the eagle-kind excepted, after the young have come to maturity, are forever abandoned by the parents.

To deſcribe minutely the neſts of birds would be a vain attempt. Such deſcriptions could not convey an adequate idea of their architecture to a perſon who had never ſeen one of thoſe beautiful and commodious habitations, which even aſtoniſh and excite the amazement of children.

The different orders of birds exhibit great variety in the materials and ſtructure of their neſts. Thoſe of the rapacious tribes are in general rude, and compoſed of coarſe materials, as dried twigs, bents, &c. But, they are often lined with ſoft ſubſtances. They build in elevated rocks, ruinous and ſequeſtered caſtles and towers, and in other ſolitary retirements.. The aiery or neſt of the eagle

is quite flat, and not hollow, like thoſe of other birds. The male and female commonly place their neſt between two rocks, in a dry and inacceſſible ſituation. The ſame neſt, it is ſaid, ſerves the eagle during life. The ſtructure is ſo conſiderable, and compoſed of ſuch ſolid materials, that it may laſt many years. Its form reſembles that of a floor. Its baſis conſiſts of ſticks about five or ſix feet in length, which are ſupported at each end, and theſe are covered with ſeveral layers of ruſhes and heath. An eagle's neſt was found in the Peak of Derbyſhire, which Willoughby deſcribes in the following manner: 'It was 'made of great ſticks, reſting one end on the edge of a 'rock, the other on a birch tree. Upon theſe was a layer 'of ruſhes, and over them a layer of heath, and upon the 'heath ruſhes again; upon which lay one young, and an 'addle egg; and by them a lamb, a hare, and three heath-'pouts. The neſt was about two yards ſquare, and had 'no hollow in it.' But the butcher-birds, or ſhrikes, which are leſs rapacious than eagles and hawks, build their habitations in ſhrubs and buſhes, and employ moſs, wool, and other ſoft materials.

The birds belonging to the order of *Pies* in the ingenious Mr. Pennant's Genera of Birds, are extremely irregular in conſtructing their neſts. The common magpies build their neſts in trees, and their ſtructure is admirably contrived for affording warmth and protection to the young. The neſt is not open at top: It is covered, in the moſt dexterous manner, with an arch or dome, and a ſmall opening in the ſide of it is left, to give the parents an opportunity of paſſing in and out at their pleaſure. To protect their eggs and young from the attacks of other animals, the magpies place, all round the external ſurface of their neſt, ſharp briars and thorns. The long-tailed titmouſe, or ox-eye, builds nearly like the wren, but with ſtill greater art. With the ſame materials as the reſt of the ſtructure, the titmouſe builds an arch over the top of the neſt, which reſembles an egg erected upon one end, and leaves a ſmall hole in the ſide for a paſſage. Both eggs and young, by this contrivance, are defended from the injuries of the air, rain, cold, &c. That the young

may

may have a ſoft and warm bed, ſhe lines the inſide of the neſt with feathers, down, and cobwebs. The ſides and roof are compoſed of moſs and wool interwoven in the moſt curious and artificial manner.

In treating of inſtinct, it was mentioned, that, in warm climates, many ſmall birds ſuſpended their neſts on tender twigs of trees, to prevent them from being deſtroyed by the monkeys. In Europe, there are only three birds which build penſile neſts, namely, the common oriola *, the *parus pendulinus*, or hang-neſt titmouſe; and another penſile neſt, belonging to ſome unknown bird, was lately diſcovered by Mr. Pennant, near the houſe of Blair in Athole, in the north of Scotland. 'In a ſpruce fir-tree,' Mr. Pennant remarks, 'was a hang-neſt of ſome unknown 'bird, ſuſpended at the four corners to the boughs. It 'was open at top, an inch and a half diameter, and two 'deep; the ſides and bottom thick; the materials moſs, 'worſted, and birch bark, lined with feathers †.'

Mr. Pennant, in his Indian Zoology, gives the following curious account of the manner in which the motacilla ſutoria, or tailor-bird, builds its neſt. 'Had providence,' Mr. Pennant remarks, 'left the feathered tribes unendow-'ed with any particular inſtinct, the birds of the torrid 'zone would have built their neſts in the ſame unguarded 'manner as thoſe of Europe; but there the leſſer ſpecies, 'having a certain preſcience of the dangers that ſurround 'them, and of their own weakneſs, ſuſpend their neſts at 'the extreme branches of the trees: They are conſcious 'of inhabiting a climate replete with enemies to them and 'their young; with ſnakes that twine up the bodies of 'the trees, and apes that are perpetually in ſearch of 'prey; but, heaven-inſtructed, they elude the gliding of 'the one, and the activity of the other.—The brute crea-'tion are more at enmity with one another than in other 'climates; and the birds are obliged to exert an unuſual 'artifice in placing their little broods out of the reach of 'an invader. Each aims at the ſame end, though by dif-'ferent means; ſome form their penſile neſt in ſhape of 'a purſe, deep and open at top, others with a hole in the

Oo 'ſide,

* Oriolus *Galbula*.

† Pennant's Tour, vol. 1. pag. 104. 3d edit. S.

'side, and others, still more cautious, with an entrance at 'the very bottom, forming their lodge near the summit*. 'But the tailor-bird seems to have greater diffidence than 'any of the others: It will not trust its nest even to the 'extremity of a slender twig, but makes one more ad-'vance to safety by fixing it to the leaf itself. It picks 'up a dead leaf, and, surprising to relate, sews it to the 'side of a living one †, its slender bill being its needle, 'and its thread some fine fibres, the lining feathers, gossa-'mer, and down. Its eggs are white, the colour of the 'bird light yellow; its length three inches; its weight 'only three sixteenths of an ounce; so that the mate-'rials of the nest, and its own size, are not likely to 'draw down a habitation that depends on so slight a ten-'ture ‡.'

Birds of the gallinaceous or poultry kind lay their eggs on the ground. Some of them scrape a kind of hole in the earth, and line it with a little long grass or straw.

It is a singular, though a well-attested fact, that the cuckow makes no nest, and neither hatches nor feeds her own young. 'The hedge-sparrow,' says Mr. Willoughby, 'is the cuckow's nurse, but not the hedge-sparrow 'only, but also ring-doves, larks, finches. I myself, with 'many others, have seen a wag-tail feeding a young cuc-'kow. The cuckow herself builds no nest; but having 'found the nest of some little bird, she either devours or 'destroys the eggs she there finds, and, in the room thereof, 'lays one of her own, and so forsakes it. The silly bird re-'turning, sits on this egg, hatches it, and, with a great deal 'of care and toil, broods, feeds, and cherishes the young 'cuckow for her own, until it be grown up, and able to fly 'and shift for itself. Which thing seems so strange, mon-'strous, and absurd, that for my part I cannot sufficiently 'wonder there should be such an example in Nature; nor 'could I ever have been induced to believe that such a thing 'had

* This instinct prevails also among the birds on the banks of the Gambia, in Africa, which abounds with monkeys and snakes; others, for the same end, make their nest in holes of the banks that overhang that vast river. Purchas, vol. 2. pag. 1576. S.

† A nest of this bird is preserved in the British Museum. S.

‡ Pennant's Indian Zoology, pag. 7. S.

'had been done by Nature's inſtinct, had I not with mine 'own eyes ſeen it. For Nature, in other things, is wont 'conſtantly to obſerve one and the ſame law and order, 'agreeable to the higheſt reaſon and prudence; which in 'this caſe is, that the dams make neſts for themſelves, if 'need be, ſit upon their own eggs, and bring up their own 'young after they are hatched*.' This œconomy, in the hiſtory of the cuckow, is not only ſingular, but ſeems to contradict one of the moſt univerſal laws eſtabliſhed among animated beings, and particularly among the feathered tribes, namely, the hatching and rearing of their offspring. Still, however, like the oſtrich in very warm climates, though the cuckow neither hatches nor feeds her young, ſhe places her eggs in ſituations where they are both hatched and her offspring brought to maturity. Here the ſtupidity of the one animal makes it a dupe to the rapine and chicane of the other; for the cuckow always deſtroys the eggs of the ſmall bird before ſhe depoſits her own.

Moſt of the paſſerine or ſmall birds build their neſts in hedges, ſhrubs, or buſhes; though ſome of them, as the lark and the goat-ſucker, build upon the ground. The neſts of ſmall birds are more delicate in their ſtructure and contrivance than thoſe of the larger kinds. As the ſize of their bodies, and likewiſe that of their eggs, are ſmaller, the materials of which their neſts are compoſed are generally warmer. Small bodies retain heat a ſhorter time than thoſe which are large. Hence the eggs of ſmall birds require a more conſtant ſupply of heat than thoſe of greater dimenſions. Their neſts, accordingly, are built proportionally warmer and deeper, and they are lined with ſofter ſubſtances. The larger birds, of courſe, can leave their eggs for ſome time with impunity; but the ſmaller kinds ſit moſt aſſiduouſly; for, when the female is obliged to go abroad in queſt of food, the neſt is always occupied by the male. When a neſt is finiſhed, nothing can exceed the dexterity of both male and female in concealing it from the obſervation of man, and of other deſtructive animals. If it is built in buſhes, the pliant branches are diſpoſed in ſuch a manner as to hide it entirely

* Willoughby's Ornithology, pag. 98. S.

tirely from view. To conceal her retreat, the chaffinch covers the outſide of her neſt with moſs, which is commonly of the ſame colour with the bark of the tree on which ſhe builds. The common ſwallow builds its neſt on the tops of chimneys; and the martin attaches hers to the corners of windows, or under the eaves of houſes. Both employ the ſame materials. The neſt is built with mud well tempered by the bill, and moiſtened with water to make it more firmly cohere; and the mud or clay is kept ſtill firmer by a mixture of ſtraw or graſs. Within it is neatly lined with feathers. Willoughby, on the authority of Bontius, informs us, 'That, on the ſea-coaſt 'of the kingdom of China, a ſort of ſmall party-coloured 'birds, of the ſhape of ſwallows, at a certain ſeaſon of 'the year, viz. their breeding time, come out of the mid-'land country to the rocks; and from the foam or froth 'of the ſea-water daſhing and breaking againſt the bot-'tom of the rocks, gather a certain clammy, glutinous 'matter, perchance the ſperm of whales, or other fiſhes, 'of which they build their neſts, wherein they lay their 'eggs, and hatch their young. Theſe neſts the Chineſe 'pluck from the rocks, and bring them in great numbers 'into the Eaſt-Indies to ſell; which are eſteemed by glut-'tons great delicacies, who, diſſolving them in chicken or 'mutton broth, are very fond of them, preferring them 'far before oyſters, muſhrooms, or other dainty and lic-'keriſh morſels which moſt gratify the palate.—Theſe 'neſts are of a hemiſpherical figure, of the bigneſs of a 'gooſe-egg, and of a ſubſtance reſembling iſinglaſs *.'

Moſt

* Willoughby's Ornithology, pag. 215. S.——The reader, who is deſirous of receiving further information on this curious ſubject, may amuſe himſelf by conſulting the *China Illuſtrata* of the learned Kircher, pag. 199, and Kæmpfer, in his *Amœnitates Exoticæ*, pag. 833. Kircher alſo refers to two Italian authors, P. Daniel Bartolus and P. Philippus Marinus, who have both made mention of theſe eſculent neſts.—The author of the China Illuſtrata ſays, that ſome of the birds which build theſe neſts are like *ſparrows*, and that others reſemble *ſwallows*. Linnæus, who, it is probable, had never peruſed either Kircher's work, or thoſe of the two Italian hiſtorians, whoſe names I have juſt mentioned, ſeems to ſuppoſe, that theſe ſingular neſts are entirely the workmanſhip of a ſpecies of ſwallow, which he has denominated *Hirundo eſculenta*. It is deſcribed and figured in the *Herbarium Amboinenſe*, of Rumphius, by the name of *Capus marina*, and in the *Ornithologia* of Briſſon, by that of *Hirundo riparia cochinſinenſis*, vol. 2. pag. 510. t. 46. f. 2. A.

Moſt of the cloven-footed water-fowls, or waders, lay their eggs upon the ground. But, the ſpoon-bills and the common heron build large neſts in trees, and employ twigs and other coarſe materials; and the ſtorks build on churches, or on the tops of houſes. Many of the web-footed fowls lay their eggs likewiſe on the ground, as the terns, and ſome of the gulls and merganſers. But ducks pull the down from their own breaſts to afford a warmer and more comfortable bed for their young. The auks, the guillemots, and the puffins or coulternebs, lay their eggs on the naked ſhelves of high rocks. The penguins, for the ſame purpoſe, dig large and deep holes under ground.

It is not unworthy of remark, that birds uniformly proportion the dimenſions of their neſts to the number and ſize of the young to be produced. Every ſpecies lays nearly a determined number of eggs. But, if one be each day abſtracted from the neſt, the bird continues to lay daily more till her number is completed. Dr. Liſter, by this practice, made a ſwallow lay no leſs than nineteen eggs.

The habitations of *Inſects* are next to be conſidered. On this branch of the ſubject, we ſhall firſt give ſome examples of abodes conſtructed by ſolitary workers, and next of thoſe habitations which are executed by aſſociated numbers.

In ſeveral preceding parts of this work, and particularly in the chapter upon Inſtinct, the reader will find ſome inſtances of the ſkill and induſtry exhibited by inſects for the convenient lodging and protection of their young. Theſe it is unneceſſary to repeat. We ſhall therefore proceed to give ſome examples of a different kind.

There are ſeveral ſpecies of bees diſtinguiſhed by the appellation of *ſolitary*, becauſe they do not aſſociate to carry on any joint operations. Of this kind is the *maſon-bee*, ſo called becauſe it builds a habitation compoſed of ſand and mortar. The neſts of this bee are fixed to the walls of houſes, and, when finiſhed, have the appearance of irregular prominences ariſing from dirt or clay accidentally thrown againſt a wall or ſtone by the feet of horſes.

horſes. Theſe prominences are not ſo remarkable as to attract attention; but, when the external coat is removed, their ſtructure is diſcovered to be truly admirable. The interior part conſiſts of an aſſemblage of different cells, each of which affords a convenient lodgement to a white worm, pretty ſimilar to thoſe produced by the honey-bee. Here they remain till they have undergone all their metamorphoſes. In conſtructing this neſt, which is a work of great labour and dexterity, the female is the ſole operator. She receives no aſſiſtance from the male. The manner in which the female maſon-bees build their neſts, is the moſt curious branch of their hiſtory.

After chooſing a part of a wall on which ſhe is reſolved to fix an habitation for her future progeny, ſhe goes in queſt of proper materials. The neſt to be conſtructed muſt conſiſt of a ſpecies of mortar, of which ſand is the baſis. She knows, like human builders, that every kind of ſand is not equally proper for making good mortar. She goes, therefore, to a bed of ſand, and ſelects, grain by grain, the kind which is beſt to anſwer her purpoſe. With her teeth, which are as large and as ſtrong as thoſe of the honey-bee, ſhe examines and brings together ſeveral grains. But ſand alone will not make mortar. Recourſe muſt be had to a cement ſimilar to the ſlacked lime employed by maſons. Our bee is unacquainted with lime, but ſhe poſſeſſes an equivalent in her own body. From her mouth ſhe throws out a viſcid liquor, with which ſhe moiſtens the firſt grain pitched upon. To this grain ſhe cements a ſecond, which ſhe moiſtens in the ſame manner, and to the former two ſhe attaches a third, and ſo on, till ſhe has formed a maſs as large as the ſhot uſually employed to kill hares. This maſs ſhe carries off in her teeth to the place ſhe had choſen for erecting her neſt, and makes it the foundation of the firſt cell. In this manner ſhe labours inceſſantly till the whole cells are completed, a work which is generally accompliſhed in five or ſix days. All the cells are ſimilar, and nearly equal in dimenſions. Before they are covered, their figure reſembles that of a thimble. She never begins to make a ſecond till the firſt be finiſhed. Each cell is about an inch

high,

high, and nearly half an inch in diameter. But the labour of building is not the only one this female bee has to undergo. When a cell has been raiſed to one half or two thirds of its height, another occupation commences. She ſeems to know the quantity of food that will be neceſſary to nouriſh the young that is to proceed from the egg, from its excluſion till it acquires its full growth, and paſſes into the chryſalis ſtate. The food which is prepared for the ſupport of the young worm conſiſts of the farina or powder of flowers, diluted with honey, which forms a kind of pap. Before the cell is entirely finiſhed, the maſon-bee collects from the flowers, and depoſits in the cell, a large quantity of farina, and afterwards diſgorges upon it as much honey as dilutes it, and forms it into a kind of paſte, or ſyrup. When this operation is performed, ſhe completes her cell, and, after depoſiting an egg in it, covers the mouth of it with the ſame mortar ſhe uſes in building her neſt. The egg is now incloſed on all ſides in a walled habitation hermetically ſealed. A ſmall quantity of air, however, gets admiſſion to the worm, otherwiſe it could not exiſt. Reaumur diſcovered that air actually penetrated through this ſeemingly-compact maſon-work.

As ſoon as the firſt cell is completed, the maſon-bee lays the foundation of another. In the ſame neſt ſhe often conſtructs ſeven or eight cells, and ſometimes only three or four. She places them near each other, but not in any regular order. This induſtrious animal, after all her cells are conſtructed, filled with proviſions, and ſealed, covers the whole with an envelope of the ſame mortar, which, when dry, is as hard as ſtone. The neſt now is commonly of an oblong or roundiſh figure, and the external cover is compoſed of coarſer ſand than that of the cells. As the neſts are almoſt as durable as the walls on which they are placed, they are often, in the following ſeaſon, occupied and repaired by a ſtranger bee. Though incloſed with two hard walls, when the fly emerges from the chryſalis ſtate, it firſt gnaws with its teeth a paſſage through the wall that ſealed up the mouth of its cell; afterwards, with the ſame inſtruments, it pierces the

the ſtill ſtronger and more compact cover which inveſts the whole neſt; at laſt it eſcapes into the open air, and, if a female, in a ſhort time, conſtructs a neſt of the ſame kind with that which the mother had made. To all theſe facts, Du Hamel, Reaumur, and many other naturaliſts of credit and reputation, have been repeatedly eye-witneſſes.

From the hardneſs of the materials with which the maſon-bee conſtructs her neſt, from the induſtry and dexterity ſhe employs to protect her progeny from enemies of every kind, one ſhould naturally imagine that the young worms were in perfect ſafety, and that their caſtle was impregnable. But, notwithſtanding all theſe favourable precautions, the young of the maſon-bee are often devoured by the inſtinctive dexterity of certain ſpecies of four-winged inſects, diſtinguiſhed by the name of *ichneumon flies*. Theſe flies, when the maſon-bee has nearly completed a cell, and filled it with proviſions, depoſit their own eggs in her cell. After the eggs of the ichneumon flies are hatched, their worms devour not only the proviſions laid up by the maſon-bee, but even her progeny whom ſhe had laboured ſo hard, and with ſo much art and ingenuity, to protect. But the maſon-bee has an enemy ſtill more formidable. A certain fly employs the ſame ſtratagem of inſinuating an egg into one of her cells before it is completed. From this egg proceeds a ſtrong and rapacious worm, armed with prodigious fangs. The devaſtations of this worm are not confined to one cell. He often pierces through each cell in the neſt, and ſucceſſively devours both the maſon-worms, and the proviſions ſo anxiouſly laid up for their ſupport by the mother. This ſtranger-worm is afterwards transformed into a fine beetle, who is enabled to pierce the neſt, and to make his eſcape.

The operations of another ſpecies of ſolitary bees, called *wood-piercers*, merit attention. Theſe bees are larger than the queens of the honey-bee. Their bodies are ſmooth, except the ſides, which are covered with hair. In the ſpring, they frequent gardens, and ſearch for rotten, or at leaſt dead wood, in order to make a habitation

bitation for their young. When a female of this ſpecies, for ſhe receives no aſſiſtance from the male, has ſelected a piece of wood, or a decayed tree, ſhe commences her labour by making a hole in it, which is generally directed toward the axis of the tree. When ſhe has advanced about half an inch, ſhe alters the direction of the hole, and conducts it nearly parallel to the axis of the wood. The ſize of her body requires that this hole ſhould have a conſiderable diameter. It is often ſo large as to admit the finger of a man, and it ſometimes extends from twelve to fifteen inches in length. If the thickneſs of the wood permits, ſhe makes three or four of theſe long holes in its interior part. M. de Reaumur found three of theſe parallel holes in an old eſpalier poſt. Their diameters exceeded half an inch. This labour, for a ſingle bee, is prodigious; but, in executing it, ſhe conſumes weeks, and even months.

Around the foot of a poſt or piece of wood where one of theſe bees are working, little heaps of timber-duſt are always found lying on the ground. Theſe heaps daily increaſe in magnitude, and the particles of duſt are as large as thoſe produced by a hand-ſaw. The two teeth with which the animal is provided are the only inſtruments ſhe employs in making ſuch conſiderable perforations. Each tooth conſiſts of a ſolid piece of ſhell, which in ſhape reſembles an auger. It is convex above, concave below, and terminates in a ſharp but ſtrong point.

Theſe long holes are deſigned for lodgings to the worms that are to proceed from the eggs which the bee is ſoon to depoſit in them. But, after the holes are finiſhed, her labour is by no means at an end. The eggs muſt not be mingled, or piled above each other. Every ſeparate worm muſt have a diſtinct apartment, without any communication with the others. Each long hole or tube, accordingly, is only the outer walls of a houſe which is to conſiſt of many chambers ranged one above another. A hole of about twelve inches in length ſhe divides into ten or twelve ſeparate apartments, each of which is about an inch high. The roof of the loweſt room is the floor of the ſecond, and ſo on to the uppermoſt. Each floor is about

the thicknefs of a French crown. The floors or divifions are compofed of particles of wood cemented together by a glutinous fubftance from the animal's mouth. In making a floor, fhe commences with gluing an annular plate of wood-duft round the internal circumference of the cavity. To this plate fhe attaches a fecond, to the fecond a third, and to the third a fourth, till the whole floor is completed. The undermoft cell requires only a roof, and this roof is a floor to the fecond, &c.

We have hitherto defcribed the wonderful affiduity of this animal in conftructing her cells. But this operation, though great, and feemingly-fuperior to the powers of a creature fo fmall, is not her only labour. Before roofing in the firft cell, fhe fills it with a pafte or pap, compofed of the farina of flowers moiftened with honey. The quantity of pafte is equal to the dimenfions of the cell, which is about an inch high, and half an inch in diameter. Into this pafte, which is to nourifh the future worm, fhe depofits an egg. Immediately after this operation, fhe begins to form a roof, which not only inclofes the firft cell, but ferves as a floor to the fecond. The fecond cell fhe likewife fills with pafte, depofits an egg, and then covers the whole with another roof. In this manner fhe proceeds, till fhe has divided the whole tube into feparate cells. A fingle tube frequently contains from ten to a dozen of thefe cells. When the cells are all inclofed, the bufinefs of this laborious bee is finifhed, and fhe takes no more charge of her future progeny. The attention and folicitude beftowed by many other animals, in rearing their young, are exerted after birth. But, in the wood-piercing bee, as well as in many other infects, this inftinctive attachment is reverfed. All her labours and all her cares are exerted before fhe either fees her offspring, or knows that they are to exift. But, after the defcription that has been given of her amazing operations, fhe will not be confidered as an unnatural mother. With aftonifhing induftry and perfeverance, fhe not only furnifhes her young with fafe and convenient lodgings, but lays up for them ftores of provifions fufficient to fupport them till their final metamorphofis into flies,

flies, when the new females perform the ſame almoſt incredible operations for the protection and ſuſtenance of their own offspring. When the young worm is hatched, it has ſcarcely ſufficient ſpace to turn itſelf in the cell, which is almoſt entirely filled with the pappy ſubſtance formerly mentioned. But, as this ſubſtance is gradually devoured by the worm, the ſpace in the cell neceſſarily enlarges in proportion to the growth and magnitude of the animal.

We are informed by M. de Reaumur *, that M. Pitot furniſhed him with a piece of wood, not exceeding an inch and a half in diameter, which contained the cells of a wood-piercing bee. He cut off as much of the wood as was ſufficient to expoſe two of the cells to view, in each of which was a worm. The aperture he had made, to prevent the injuries of the air, he cloſed, by paſting on a bit of glaſs. The cells were then almoſt entirely filled with paſte. The two worms were exceedingly ſmall, and, of courſe, occupied but little ſpace between the walls of the cells and the maſs of paſte. As the animals increaſed in ſize, the paſte daily diminiſhed. He began to obſerve them on the 12th day of June; and, on the 27th of the ſame month, the paſte in each cell was nearly conſumed, and the worm, folded in two, occupied the greater part of its habitation. On the 2d of July, the proviſions of both worms were entirely exhauſted; and, beſide the worms themſelves, there remained in the cells only a few ſmall, black, oblong grains of excrement. The five or ſix following days they faſted, which ſeemed to be a neceſſary abſtinence, during which they were greatly agitated. They often bended their bodies, and elevated and depreſſed their heads. Theſe movements were preparatory to the great change the animals were about to undergo. Between the 7th and 8th of the ſame month, they threw off their ſkins, and were metamorphoſed into nymphs. On the 30th of July, theſe nymphs were transformed into flies ſimilar to their parents. In a range of cells, the worms are of different ages, and, of courſe, of different ſizes. Thoſe in the lower cells are older than thoſe

* Tom. 11. pag. 58. 12mo edit. S.

thofe in the fuperior; becaufe, after the bee has filled with pafte and inclofed its firft cell, a confiderable time is requifite to collect provifions, and to form partitions for every fucceffive and fuperior cell. The former, therefore, muft be transformed into nymphs and flies before the latter. Thefe circumftances are apparently forefeen by the common mother; for, if the undermoft worm, which is oldeft, and sooneft transformed, were to force its way upward, which it could eafily do, it would not only difturb, but infallibly deftroy, all thofe lodged in the fuperior cells. But Nature has wifely prevented this devaftation; for the head of the nymph, and confequently of the fly, is always placed in a downward direction. Its firft inftinctive movements muft, therefore, be in the fame direction. That the young flies may efcape from their refpective cells, the mother digs a hole at the bottom of the long tube, which makes a communication with the undermoft cell and the open air. Sometimes a fimilar paffage is made near the middle of the tube. By this contrivance, as all the flies inftinctively endeavour to cut their way downward, they find an eafy and convenient paffage; for they have only to pierce the floor of their cells, which they readily perform with their teeth.

Another fmall fpecies of folitary bees dig holes in the earth to make a convenient habitation for their young. Their nefts are compofed of cylindrical cells fixed to one another, and each of them, in figure, refembles a thimble. Their bottom, of courfe, is convex and rounded. The bottom of the fecond is inferted into the entry of the firft; and the entry of the fecond receives the bottom of the third. They are not all of the fame length. Some of them are five lines long, others only four, and their diameters feldom exceed two lines. Sometimes only two of thefe cells are joined together; and, at other times, we find three or four, which form a kind of cylinder. This cylinder is compofed of alternate bands of two different colours: Thofe of the narroweft, at the juncture of two cells, are white, and thofe of the broadeft are of a reddifh brown. The cells confift of a number of fine membranes, formed of a glutinous and tranfparent fub-

ftance

ſtance from the animal's mouth. Each cell our bee fills with the farina of flowers diluted with honey, and in this paſte ſhe depoſits an egg. She then covers the cell, by gluing to its mouth a fine cellular ſubſtance taken from the leaves of ſome plant; and in this manner ſhe proceeds till her cylindrical neſt is completed. The worms which are hatched from the eggs feed upon the paſte, ſo carefully laid up for them by the mother, till they are transformed into flies ſimilar to their parents.

Among waſps, as well as bees, there are ſolitary ſpecies, which carry on no joint operations. Theſe ſolitary waſps are not leſs ingenious in conſtructing proper habitations for their young, nor leſs provident in laying up for them a ſtore of nouriſhment ſufficient to ſupport them till they are transformed into flies, or have become perfect animals*. But, to give a detailed deſcription of their operations would lead us into a prolixity of which the plan of our work does not admit.

On this ſubject, however, it cannot eſcape obſervation, that all the ſagacity and laborious induſtry exerted in the various inſtances of animal architecture above deſcribed, have one uniform tendency. They are all deſigned for the multiplication, protection, and nouriſhment of offſpring. But many of them are ſo artful, and require ſuch perſevering labour, that the human mind is bewildered when it attempts to account for them. If we attend to the operations of quadrupeds, of birds, and of inſects, moſt of them, like pregnant women, ſeem to know, from their own feelings, and foreſight, not only their preſent condition, but what futurity is to produce. To ſolve this problem, recourſe has been had by Des Cartes, by Buffon, and by other philoſophers, to conformation of body and mechanical impulſe. Their reaſonings, however, though often ingenious, involve the ſubject in tenfold obſcurity. We can hardly ſuppoſe that the animals actually foreſee what is to happen, becauſe, at firſt, they have not had even the aid of experience; and, particularly in ſome of the inſect tribes, the parents are dead before their young are produced. Pure inſtincts of this kind,

* See page 128. S.

kind, therefore, muſt be referred to another ſource. In a chain of reaſoning concerning the operations of Nature, ſuch is the conſtitution of our minds, that we are under the neceſſity of reſorting to an ultimate cauſe. What that cauſe is, it is the higheſt preſumption in man to pretend to define. But, though we muſt forever remain ignorant of the cauſe, we are enabled to trace, and even to underſtand, partially, ſome of the effects; and, from theſe effects, we perceive the moſt conſummate wiſdom, the moſt elegant and perfect contrivances to accompliſh the multifarious and wonderful intentions of Nature. In contemplating the operations of animals, from man down to the ſeemingly moſt contemptible inſect, we are neceſſarily compelled to refer them to pure inſtincts, or original qualities of mind, variegated by Nature according as the neceſſities, preſervation, and continuation of the different ſpecies require. Let any man try to proceed a ſtep farther, and, however he may deceive himſelf, and flatter his own vanity, he muſt find, at laſt, that he is clouded in obſcurity, and that men who have a more correct and unprejudiced mode of thinking will brand him with abſurdity, and of acting in direct oppoſition to the conſtitution and frame of the human mind.

I ſhall now give ſome examples of the operations of aſſociating-inſects, who conſtruct habitations by exerting a common and mutual labour.

The ſkill and dexterity of the *honey-bees*, diſplayed in the conſtruction of their combs or neſts, have at all times called forth the admiration of mankind. They are compoſed of cells regularly applied to each others ſides. Theſe cells are uniform hexagons or ſix-ſided figures. In a bee-hive, every part is arranged with ſuch ſymmetry, and ſo finely finiſhed, that, if limited to the ſame materials, the moſt expert workman would find himſelf unqualified to conſtruct a ſimilar habitation, or rather a ſimilar city.

Moſt Natural Hiſtorians have celebrated bees for their wiſdom, for the perfection and harmony of their republican government, and for their perſevering induſtry and wonderful œconomy. All theſe ſplendid talents, however,

the late ingenious Count de Buffon has endeavoured to perſuade us, are only reſults of pure mechaniſm. But this is not the proper place to enter into a diſcuſſion of this point. It will fall more naturally to be treated of when we come to deſcribe the ſocieties eſtabliſhed among different gregarious animals. We ſhall, therefore, at preſent, confine ourſelves chiefly to the mode in which bees conſtruct their habitations.

In the formation of their combs, bees ſeem to reſolve a problem which would not be a little puzzling to ſome geometers, namely, A quantity of wax being given, to make of it equal and ſimilar cells of a determined capacity, but of the largeſt ſize in proportion to the quantity of matter employed, and diſpoſed in ſuch a manner as to occupy in the hive the leaſt poſſible ſpace. Every part of this problem is completely executed by the bees. By applying hexagonal cells to each other's ſides, no void ſpaces are left between them; and, though the ſame end might be accompliſhed by other figures, yet they would neceſſarily require a greater quantity of wax. Beſides, hexagonal cells are better fitted to receive the cylindrical bodies of theſe inſects. A comb conſiſts of two ſtrata of cells applied to each other's ends. This arrangement both ſaves room in the hive, and it gives a double entry into the cells of which the comb is compoſed. As a farther ſaving of wax, and preventing void ſpaces, the baſes of theſe cells in one ſtratum of a comb ſerve for baſes to the oppoſite ſtratum. In a word, the more minutely the conſtruction of theſe cells are examined, the more will the admiration of the obſerver be excited. The walls of the cells are ſo extremely thin, that their mouths would be in danger of ſuffering by the frequent entering and iſſuing of the bees. To prevent this diſaſter, they make a kind of ring round the margin of each cell, and this ring is three or four times thicker than the walls.

It is difficult to perceive, even with the aſſiſtance of glaſs-hives, the manner in which bees operate when conſtructing their cells. They are ſo eager to afford mutual aſſiſtance, and, for this purpoſe, ſo many of them crowd together, and are perpetually ſucceeding each other, that

their

their individual operations can feldom be diftinctly obferved. It has, however, been plainly difcovered, that their two teeth are the only inftruments they employ in modelling and polifhing the wax. With a little patience and attention, we perceive cells juft begun: We likewife remark the quicknefs with which a bee moves its teeth againft a fmall portion of the cell. This portion the animal, by repeated ftrokes on each fide, fmooths, renders compact, and reduces to a proper thinnefs of confiftence. While fome of the hive are lengthening their hexagonal tubes, others are laying the foundations of new ones. In certain circumftances, when extremely hurried, they do not complete their new cells, but leave them imperfect till they have begun a number fufficient for their prefent exigencies. When a bee puts its head a little way into a cell, we eafily perceive it fcraping the walls with the points of its teeth, in order to detach fuch ufelefs and irregular fragments as may have been left in the work. Of thefe fragments the bee forms a ball about the fize of a pin-head, comes out of the cell, and carries this wax to another part of the work where it is needed. It no fooner leaves the cell than it is fucceeded by another bee, which performs the fame office, and in this manner the work is fucceffively carried on till the cell is completely polifhed.

The cells of bees are defigned for different purpofes. Some of them are employed for the accumulation and prefervation of honey. In others, the female depofits her eggs, and from thefe eggs worms are hatched, which remain in the cells till their final transformation into flies. The drones, or males, are larger than the common, or working, bees; and the queen, or mother of the hive, is much larger than either. A cell deftined for the lodgement of a male or female worm muft, therefore, be confiderably larger than the cells of the fmaller working bees. The number of cells deftined for the reception of the working bees far exceeds thofe in which the males are lodged. The honey-cells are always made deeper and more capacious than the others. When the honey collected is fo abundant that the veffels cannot contain it, the bees lengthen, and of courfe deepen, the honey-cells.

Their mode of working, and the diſpoſition and diviſion of their labour, when put into an empty hive, do much honour to the ſagacity of bees. They immediately begin to lay the foundations of their combs, which they execute with ſurpriſing quickneſs and alacrity. Soon after they begin to conſtruct one comb, they divide into two or three companies, each of which, in different parts of the hive, is occupied with the ſame operations. By this diviſion of labour, a greater number of bees have an opportunity of being employed at the ſame time, and, conſequently, the common work is ſooner finiſhed. The combs are generally arranged in a direction parallel to each other. An interval, or ſtreet, between the combs is always left, that the bees may have a free paſſage, and an eaſy communication with the different combs in the hive. Theſe ſtreets are juſt wide enough to allow two bees to paſs one another. Beſide theſe parallel ſtreets, to ſhorten their journey when working, they leave ſeveral round croſs paſſages, which are always covered.

Hitherto we have chiefly taken notice of the manner in which bees conſtruct and poliſh their cells, without treating of the materials they employ. We have not marked the difference between the crude matter collected from flowers and the true wax. Every body knows that bees carry into their hives, by means of their hind thighs, great quantities of the farina, or duſt, of flowers. After many experiments made by Reaumur, with a view to diſcover whether this duſt contained real wax, he was obliged to acknowledge, that he could never find that wax formed any part of its compoſition. He at length diſcovered, that wax was not a ſubſtance produced by the mixture of farina with any glutinous ſubſtance, nor by trituration, or any mechanical operation. By long and attentive obſervation, he found that the bees actually eat the farina which they ſo induſtriouſly collect; and that this farina, by an animal proceſs, is converted into wax. This digeſtive proceſs, which is neceſſary to the formation of wax, is carried on in the ſecond ſtomach, and perhaps in the inteſtines of bees. After knowing the place where this operation is performed, chymiſts will probably allow, that

it is equally difficult to make real wax with the farina of flowers, as to make chyle with animal or vegetable ſubſtances, a work which is daily executed by our own ſtomach and inteſtines, and by thoſe of other animals. Reaumur likewiſe diſcovered, that all the cells in a hive were not deſtined for the reception of honey, and for depoſiting the eggs of the female, but that ſome of them were employed as receptacles for the farina of flowers, a ſpecies of food that bees find neceſſary for the formation of wax, which is the great baſis and raw material of all their curious operations. When a bee comes to the hive with its thighs filled with farina, it is often met near the entrance by ſome of its companions, who firſt take off the load, and then devour the proviſions ſo kindly brought to them. But, when none of the bees employed in the hive are hungry for this ſpecies of food, the carriers of the farina depoſit their loads in cells prepared for that purpoſe. To theſe cells the bees reſort, when the weather is ſo bad that they cannot venture to go to the fields in queſt of freſh proviſions. The carrying bees, however, commonly enter the hive loaded with farina. They walk along the combs beating and making a noiſe with their wings. By theſe movements they ſeem to announce their arrival to their companions. No ſooner has a loaded bee made theſe movements, than three or four of thoſe within leave their work, come up to it, and firſt take off its load, and then eat the materials it has brought. As a farther evidence that the bees actually eat the farina of flowers, when the ſtomach and inteſtines are laid open, they are often found to be filled with this duſt, the grains of which, when examined by the microſcope, have the exact figure, colour, and conſiſtence of farina, taken from the antheræ of particular flowers. After the farina is digeſted, and converted into wax, the bees poſſeſs the power of bringing it from their ſtomachs to their mouths. The inſtrument they employ in furniſhing materials for conſtructing their waxen cells is their tongue. This tongue is ſituated below the two teeth or fangs. When at work, the tongue may be ſeen by the aſſiſtance of a lens and a glaſs-hive. It is then in perpetual motion, and its moti-

ons are extremely rapid. Its figure continually varies. Sometimes it is more ſharp, at others it is flatter, and ſometimes it is or more leſs concave, and partly covered with a moiſt paſte or wax. By the different movements of its tongue, the bee continues to ſupply freſh wax to the two teeth, which are employed in raiſing and faſhioning the walls of its cell, till they have acquired a ſufficient height. As ſoon as the moiſt paſte or wax dries, which it does almoſt inſtantaneouſly, it then aſſumes all the appearances and qualities of common wax. There is a ſtill ſtronger proof that wax is the reſult of an animal proceſs. When bees are removed into a new hive, and cloſely confined from the morning to the evening, if the hive chances to pleaſe them, in the courſe of this day ſeveral waxen cells will be formed, without the poſſibility of a ſingle bee's having had acceſs to the fields. Beſides, the rude materials, or the farina of plants, carried into the hive, are of various colours. The farina of ſome plants employed by the bees is whitiſh; in others it is of a fine yellow colour; in others it is almoſt entirely red; and in others it is green. The combs conſtructed with theſe differently-coloured materials are, however, uniformly of the ſame colour. Every comb, eſpecially when it is newly made, is of a pure white colour, which is more or leſs tarniſhed by age, the operation of the air, or by other accidental circumſtances. To bleach wax, therefore, requires only the art of extracting ſuch foreign bodies as may have inſinuated themſelves into its ſubſtance, and changed its original colour.

Bees, from the nature of their conſtitution, require a warm habitation. They are likewiſe extremely ſolicitous to prevent inſects of any kind from getting admittance into their hives. To accompliſh both theſe purpoſes, when they take poſſeſſion of a new hive, they carefully examine every part of it, and, if they diſcover any ſmall holes or chinks, they immediately paſte them firmly up with a reſinous ſubſtance which differs conſiderably from wax. This ſubſtance was not unknown to the ancients. Pliny mentions it under the name of *propolis*, or bee-glue. Bees uſe the propolis for rendering their hives more cloſe and perfect, in preference to wax, becauſe the former is

more

more durable, and more powerfully refifts the viciffitudes of weather, than the latter. This glue is not, like wax, procured by an animal procefs. The bees collect it from different trees, as the poplars, the birches, and the willows. It is a complete production of Nature, and requires no addition or manufacture from the animals by which it is employed. After a bee has procured a quantity fufficient to fill the cavities in its two hind thighs, it repairs to the hive. Two of its companions inftantly draw out the propolis, and apply it to fill up fuch chinks, holes, or other deficiencies, as they find in their habitation. But this is not the only ufe to which bees apply the propolis. They are extremely folicitous to remove fuch infects or foreign bodies as happen to get admiffion into the hive. When fo light as not to exceed their powers, they firft kill the infect with their ftings, and then drag it out with their teeth. But it fometimes happens that an ill-fated fnail creeps into the hive. It is no fooner perceived than it is attacked on all fides and ftung to death. But how are the bees to carry out a burden of fuch weight? This labour they know would be in vain. They are perhaps apprehenfive that a body fo laige would diffufe, in the courfe of its putrefaction, a difagreeable or noxious odour through the hive. To prevent fuch hurtful confequences, immediately after the animal's death, they embalm it, by covering every part of its body with propolis, through which no effluvia can efcape.—When a fnail with a fhell gets entrance, to difpofe of it gives much lefs trouble and expence to the bees. As foon as this kind of fnail receives the firft wound from a fting, it naturally retires within its fhell. In this cafe, the bees, inftead of pafting it all over with propolis, content themfelves with gluing all round the margin of the fhell, which is fufficient to render the animal forever immoveably fixed.

But propolis, and the materials for making wax, are not the only fubftances thefe induftrious animals have to collect. As formerly remarked, befide the whole winter, there are many days in which the bees are prevented by the weather from going abroad in queft of provifions. They are, therefore, under the neceffity of collecting, and amaffing

ſing in cells deſtined for that purpoſe, large quantities of honey. This ſweet and balſamic liquor they extract, by means of their proboſcis or trunk, from the nectariferous glands of flowers. The trunk of a bee is a kind of rough cartilaginous tongue. After collecting a few ſmall drops of honey, the animal with its proboſcis conveys them to its mouth and ſwallows them. From the œſophagus, or gullet, it paſſes into the firſt ſtomach, which is more or leſs ſwelled in proportion to the quantity of honey it contains. When empty, it has the appearance of a fine white thread: But, when filled with honey, it aſſumes the figure of an oblong bladder, the membrane of which is ſo thin and tranſparent, that it allows the colour of the liquor it contains to be diſtinctly ſeen. This bladder is well known to children who live in the country. They cruelly amuſe themſelves with catching bees, and tearing them aſunder, in order to ſuck the honey. A ſingle flower furniſhes but a ſmall quantity of honey. The bees are, therefore, obliged to fly from one flower to another till they fill their firſt ſtomachs. When they have accompliſhed this purpoſe, they return directly to the hive, and diſgorge in a cell the whole honey they have collected. It not unfrequently happens, however, that, when on its way to the hive, it is accoſted by a hungry companion. How the one can communicate its neceſſity to the other, it is perhaps impoſſible to diſcover. But the fact is certain, that, when two bees meet in this ſituation, they mutually ſtop, and the one whoſe ſtomach is full of honey extends its trunk, opens its mouth, which lies a little beyond the teeth, and, like ruminating animals, forces up the honey into that cavity. The hungry bee knows how to take advantage of this hoſpitable invitation. With the point of its trunk it ſucks the honey from the other's mouth. When not ſtopped on the road, the bee proceeds to the hive, and in the ſame manner offers its honey to thoſe who are at work, as if it meant to prevent the neceſſity of quitting their labour in order to go in queſt of food. In bad weather, the bees feed upon the honey laid up in open cells; but they never touch theſe reſervoirs when their companions are enabled to ſupply them with freſh honey from the fields.

But the mouths of thoſe cells which are deſtined for preſerving honey during winter, they always cover with a lid or thin plate of wax.

Though not ſtrictly connected wiih the preſent ſubject, we cannot refrain from giving ſome account of the ingenious Mr. Debraw's diſcoveries concerning the ſex of bees, and the manner in which their ſpecies is multiplied *. It was almoſt univerſally believed, both by ancients and moderns, that bees, like other animals, propagated by an actual intercourſe of the male and female, though it never could be perceived by the moſt attentive obſervers. Pliny remarks, that *apium coitus viſus eſt nunquam*; and even the indefatigable Reaumur, notwithſtanding the many minute reſearches and experiments he made concerning every part of the œconomy of bees, and though he repreſents the mother, or queen-bee, as a perfect Meſſalina, could never detect an actual intercourſe. From this ſingular circumſtance, Maraldi, in his obſervations upon bees †, conjectured that the eggs of bees, like thoſe of fiſhes, were impregnated after they were depoſited in the cells by the mother. He was farther confirmed in this opinion, by uniformly obſerving that a whitiſh liquid ſubſtance ſurrounded each egg which turned out to be fertile; but that thoſe eggs round which no ſuch ſubſtance was to be found were always barren. The working bees, or thoſe which collect from flowers the materials of wax, have generally been conſidered as belonging to neither ſex. But Mr. Shirach, a German Naturaliſt, in his *Hiſtory of the Queen of the Bees*, maintains, that all the common bees are females in a diſguiſed or barren ſtate; that the organs which diſtinguiſh the ſex, and particularly the ovaria, are either obliterated, or, on account of their minuteneſs, have not hitherto been diſcovered; that, in the early period of its exiſtence, every one of theſe bees is capable of becoming a queen-bee, if the community chooſe to nurſe it in a certain manner, and to raiſe it to that diſtinguiſhed rank; and that the queen-bee lays only two kinds of eggs, namely, thoſe that are to produce drones

* See Philoſophical Tranſactions, ann. 1777, Part I. page 15. S.

† Hiſt. de l'Acad. de Scien. ann. 1712. S.

drones or males, and thofe from which the working bees are to proceed.

The conjecture of Maraldi concerning the impregnation of the eggs after they are depofited in the cells, as well as the obfervations of Mr. Shirach concerning the fex of the working bees, have been completely verified by the experiments of Mr. Debraw. Both Maraldi and Reaumur had long ago difcovered, that in every hive, befide the large drones, there are males, or drones, as fmall as the working bees. By means of glafs-hives, Mr. Debraw obferved, that the queen-bee begins to depofit her eggs in the cells on the fourth or fifth day after the bees begin to work. On the firft or fecond day after the eggs are placed in the cells, he perceived feveral bees finking the pofterior parts of their bodies into each cell, where they continued but a fhort time. After they retired, he faw plainly with the naked eye a fmall quantity of whitifh liquor left in the bottom of each cell that contained an egg. Next day he found that this liquor was abforbed into the egg, which, on the fourth day, is hatched. When the worms efcape from the eggs, they are fed for the firft eight or ten days with honey by the working bees. After that period they fhut up the mouths of the cells, where the worms continue inclofed for ten days more, during which time they undergo their different transformations.

'I immerfed,' fays Mr. Debraw, 'all the bees in water; and, when they appeared to be in a fenfelefs ftate, I gently preffed every one of them between my fingers, in order to diftinguifh thofe armed with ftings from thofe that had none, which laft I might fufpect to be males. Of thefe I found fixty-feven, exactly of the fize of common bees, yielding a little whitifh liquor on being preffed between the fingers. I killed every one, and replaced the fwarm in a glafs-hive, where they immediately applied again to the work of making cells; and, on the fourth or fifth day, very early in the morning, I had the pleafure to fee the queen-bee depofiting her eggs in thefe cells, which fhe did by placing the pofterior part of her body in each of them. I continued to watch moft part of the enfuing days, but could difcover nothing of what

'I had

'I had ſeen before. The eggs, after the fourth day, in-'ſtead of changing in the manner of caterpillars, were 'found in the ſame ſtate they were in the firſt day. The 'next day about noon, the whole ſwarm forſook the hive, 'probably becauſe the animals perceived, that, without 'the aſſiſtance of males, they were unqualified to multi-'ply their ſpecies.' To ſhow the neceſſity of the eggs being fecundated by the male influence, Mr. Debraw relates an experiment ſtill more deciſive.

'I took,' ſays he, 'the brood-comb, which, as I ob-'ſerved before, had not been impregnated : I divided it 'into two parts ; one I placed under a glaſs-bell, No. 1. 'with honey-comb for the bees food ; I took care to leave 'a queen, but no drones, among the common bees I con-'fined in it. The other piece of brood-comb I placed 'under another glaſs-bell, No. 2. with a few drones, a 'queen, and a number of common bees proportioned to 'the ſize of the glaſs. The reſult was, that, in the glaſs 'No. 1. no impregnation happened ; the eggs remained 'in the ſame ſtate they were in when put into the glaſs ; 'and, upon giving the bees their liberty on the ſeventh 'day, they all flew away, as was found to be the caſe in 'the former experiment: Whereas, in the glaſs No. 2. 'I ſaw, the very day after the bees had been put under 'it, the impregnation of the eggs by the drones in every 'cell containing eggs ; the bees did not leave their hive 'on receiving their liberty ; and, in the courſe of twenty 'days, every egg underwent all the above mentioned ne-'ceſſary changes, and formed a pretty numerous young 'colony, in which I was not a little ſtartled to find two 'queens.'

The appearance of a new queen in a hive where there was no large or royal cell, made Mr. Debraw conjecture that the bees are capable, by ſome particular means, of transforming a common ſubject into a queen. To aſcertain the truth of this conjecture, he provided himſelf with four glaſs-hives, into each of which he put a piece of brood-comb taken from an old hive. Theſe pieces of brood-comb contained eggs, worms, and nymphs. In each hive he confined a ſufficient number of common

bees,

bees, and ſome drones or males, but took care that there ſhould be no queen.

‘ The bees,’ Mr. Debraw remarks, ‘ finding themſelves ‘ without a queen, made a ſtrange buzzing noiſe, which ‘ laſted near two days, at the end of which they ſettled, ‘ and betook themſelves to work. On the fourth day, I ‘ perceived in each hive the beginning of a royal cell, *a* ‘ *certain indication that one of the incloſed worms would ſoon* ‘ *be converted into a queen.* The conſtruction of the royal ‘ cell being nearly accompliſhed, I ventured to leave an ‘ opening for the bees to get out, and found that they re- ‘ turned as regularly as they do in common hives, and ‘ ſhewed no inclination to leave their habitation. But, to ‘ be brief, at the end of twenty days, I obſerved four ‘ young queens among the new progeny.’

To theſe experiments of Mr. Debraw, it was objected, that the queen-bee, beſide the eggs which ſhe depoſits in the royal cells, might likewiſe have laid royal or female eggs in the common cells; and that the pieces of brood-comb, ſo ſucceſsfully employed in his experiments for the production of a queen, had always happened to contain one of theſe royal eggs, or rather one of the worms proceeding from them. But this objection was afterwards removed by many other accurate experiments, the reſults of which were uniformly the ſame; and the objectors to Mr. Debraw's diſcovery candidly admit, that, when the community ſtands in need of a queen, the working bees poſſeſs the power of raiſing a common ſubject to the throne; and that every worm of the hive is capable, under a certain courſe of management, of becoming the mother of a numerous progeny. This metamorphoſis ſeems to be chiefly accompliſhed by a peculiar nouriſhment carefully adminiſtered to the worm by the working-bees, by which, and perhaps by other unknown means, the female organs, the germs of which previouſly exiſted in the embryo, are expanded, and all thoſe differences in form and ſize, that ſo remarkably diſtinguiſh the queen from the working-bees, are produced.

It is always a fortunate circumſtance when diſcoveries, which at firſt ſeem calculated ſolely to gratify curioſity,

are capable of being turned to the advantage of ſociety. Mr. Debraw, accordingly, has not failed to point out the advantages that may be derived from his reſearches into the œconomy and nature of bees. By his diſcovery, we are taught an eaſy mode of multiplying, without end, ſwarms, or new colonies, of theſe uſeful inſects. Beſide the great increaſe of honey, if this diſcovery were ſufficiently attended to, conſiderable ſums annually expended in importing wax into this kingdom from the Continent might be ſaved. The practice of this new art, Mr. Schirach informs us, has already extended itſelf through Upper Luſatia, the Palatinate, Bohemia, Bavaria, Sileſia, and Poland. In ſome of theſe countries, it has excited the attention, and acquired the patronage, of government. The Empreſs of Ruſſia, who never loſes ſight of a ſingle article by which the induſtry, and, of courſe, the happineſs, of her ſubjects can be augmented, has ſent a proper perſon to Klein Bautzen to be inſtructed in the general principles, and to learn all the minutiæ, of this new and important art.

Waſps, like the bees, aſſociate in great numbers, and conſtruct, with much dexterity and ſkill, a common habitation. There are many ſpecies of waſps, ſome of which unite into ſocieties, and others ſpend their lives in perfect ſolitude. But, in this place, we ſhall confine our attention to the operations of the common aſſociating waſp, an inſect ſo well known, even to children, that it requires no deſcription. Though bees, as well as waſps, are armed with a ſting, yet the former may be regarded as a placid and harmleſs race. Bees are continually occupied with their own labours. Their chief care is to defend themſelves; and they never take nouriſhment at the expence of any other animal. Waſps, on the contrary, are ferocious animals, who live entirely on rapine and deſtruction. They kill and devour every inſect that is inferior to them in ſtrength. But, though warlike and rapacious in their general manners, they are poliſhed and peaceable among themſelves. To their young they diſcover the greateſt tenderneſs and affection. For their protection and conveniency no labour is ſpared; and the habita-

habitations they conftruct do honour to their patience, addrefs, and fagacity. Their architecture, like that of the honey-bee, is fingular, and worthy of admiration; but the materials employed furnifh neither honey nor wax. Impelled by an inftinctive love of pofterity, they, with great labour, fkill, and affiduity, conftruct combs, which are likewife compofed of hexagonal or fix-fided cells. Though thefe cells are not made of wax, they are equally proper for the reception of eggs, and for affording convenient habitations to the worms which proceed from them till their transformation into wafps.

In general, the cells of the wafps are formed of a kind of paper, which, with great dexterity, is fabricated by the animals themfelves. The number of combs and cells in a wafp's neft is always proportioned to the number of individuals affociated. Different fpecies choofe different fituations for building their nefts. Some expofe their habitations to all the injuries of the air; others prefer the trunks of decayed trees; and others, as the common kind, of which we are principally treating, conceal their nefts under ground. The hole which leads to a wafp's neft is about an inch in diameter. This hole is a kind of gallery mined by the wafps, is feldom in a ftraight line, and varies in length from half a foot to two feet, according to the diftance of the neft from the furface of the ground. When expofed to view, the whole neft appears to be of a roundifh form, and fometimes about twelve or fourteen inches in diameter. It is ftrongly fortified all round with walls or layers of paper, the furface of which is rough and irregular. In thefe walls, or rather in this external covering, two holes are left for paffages to the combs. The wafps uniformly enter the neft by one hole, and go out by the other, which prevents any confufion or interruption to their common labours.

We are now arrived at the gates of this fubterraneous city, which, though fmall, is extremely populous. Upon removing the external covering, we perceive that the whole interior part confifts of feveral ftoreys or floors of combs, which are parallel to each other, and nearly in a horizontal pofition. Every ftorey is compofed of a

numerous

numerous aſſemblage of hexagonal cells, very regularly conſtructed with a matter reſembling aſh-coloured paper. Theſe cells contain neither wax nor honey, but are ſolely deſtined for containing the eggs, the worms which are hatched from them, the nymphs, and the young waſps till they are able to fly. Waſps neſts are not always compoſed of an equal number of combs. They ſometimes conſiſt of fifteen, and ſometimes of eleven only. The combs are of various diameters. The firſt, or uppermoſt, is often only two inches in diameter, while thoſe of the middle ſometimes exceed a foot. The loweſt are alſo much ſmaller than the middle ones. All theſe combs, like ſo many floors or ſtoreys ranged parallelly above each other, afford lodging to prodigious numbers of inhabitants. Reaumur computed, from the number of cells in a given portion of comb, that, in a medium-ſized neſt, there were at leaſt 10,000 cells. This calculation gives an idea of the aſtoniſhing prolific powers of theſe inſects, and of the vaſt numbers of individuals produced in a ſingle ſeaſon from one neſt; for every cell ſerves as a lodging to no leſs than three generations. Hence a moderately-ſized neſt gives birth annually to 30,000 young waſps.

The different ſtoreys of combs are always about half an inch high, which leaves free paſſages to the waſps from one part of the neſt to another. Theſe intervals are ſo ſpacious, that, in proportion to the bulk of the animals, they may be compared to great halls, or broad ſtreets. Each of the larger combs is ſupported by about fifty pillars, which, at the ſame time, give ſolidity to the fabrick, and greatly ornament the whole neſt. The leſſer combs are ſupported by the ſame ingenious contrivance. Theſe pillars are coarſe, and of a roundiſh form. Their baſes and capitals, however, are much larger in diameter than towards the middle. By the one end they are attached to the ſuperior comb, and by the other to the inferior. Thus between two combs there is always a ſpecies of ruſtic colonade. The waſps begin at the top and build downward. The uppermoſt and ſmalleſt comb is firſt conſtructed. It is attached to the ſuperior part of the exter-

nal

nal covering. The ſecond comb is fixed to the bottom of the firſt; and in this manner the animals proceed till the whole operation is completed. The connecting pillars are compoſed of the ſame kind of paper as the reſt of the neſt. To allow the waſps entries into the void ſpaces, roads are left between the combs and the external envelope or covering.

Having given a general idea of this curious edifice, it is next natural to inquire how the waſps build, and how they employ themſelves in their abodes. But, as all theſe myſteries are performed under the earth, it required much induſtry and attention to diſcover them. By the ingenuity and perſeverance of M. de Reaumur, however, we are enabled to explain ſome parts of their internal œconomy and manners. This indefatigable naturaliſt contrived to make waſps, like the honey-bees, lodge and work in glaſs-hives. In this operation he was greatly aſſiſted by the ardent affection which theſe animals have to their offspring; for he found, that, though the neſt was cut in different directions, and though it was expoſed to the light, the waſps never deſerted it, nor relaxed in their attention to their young. When placed in a glaſs-hive, they are perfectly peaceable, and never attack the obſerver, if he calmly contemplates their operations; for, naturally, they do not ſting, unleſs they are irritated.

Immediately after a waſp's neſt has been tranſported from its natural ſituation, and covered with a glaſs-hive, the firſt operation of the inſects is to repair the injuries it has ſuffered. With wonderful activity they carry off all the earth and foreign bodies that may have accidentally been conveyed into the hive. Some of them occupy themſelves fixing the neſt to the top and ſides of the hive by pillars of paper ſimilar to thoſe which ſupport the different ſtories or ſtrata of combs; others repair the breaches it has ſuſtained; and others fortify it by augmenting conſiderably the thickneſs of its external cover. This external envelope is an operation peculiar to waſps. Its conſtruction requires great labour; for it frequently exceeds an inch and a half in thickneſs, and is compoſed of a number of ſtrata or layers as thin as paper, between each

each of which there is a void ſpace. This cover is a kind of box for incloſing the combs, and defending them from the rain which occaſionally penetrates the earth. For this purpoſe it is admirably adapted. If it were one ſolid maſs, the contact of water would penetrate the whole, and reach the combs. But, to prevent this fatal effect, the animals leave conſiderable vacuities between each vaulted layer, which are generally fifteen or ſixteen in number. By this ingenious piece of architecture, one or two layers may be moiſtened with water, while the others are not in the leaſt affected.

The materials employed by waſps in the conſtruction of their neſts are very different from thoſe made uſe of by the honey-bee. Inſtead of collecting the farina of flowers, and digeſting it into wax, the waſps gnaw with their two fangs, which are ſtrong and ſerrated, ſmall fibres of wood from the ſaſhes of windows, the poſts of eſpaliers, garden doors, &c. but never attempt growing or green timber. Theſe fibres, which, though very ſlender, are often a line, or a twelfth part of an inch long. After cutting a certain number of them, the animals collect them into minute bundles, tranſport them to their neſt, and, by means of a glutinous ſubſtance furniſhed from their own bodies, form them into a moiſt and ductile paſte. Of this ſubſtance, or *papier maché*, they conſtruct the external cover, the partitions of the neſt, the hexagonal cells, and the ſolid columns which ſupport the ſeveral layers or ſtories of combs.

The conſtructing of the neſt occupies a comparatively-ſmall number of labourers. The others are differently employed. Here it is neceſſary to remark, that the republics of waſps, like thoſe of the honey-bees, conſiſt of three kinds of flies, males, females, and neuters. Like the bees, alſo, the number of neuters far ſurpaſſes thoſe of both males and females. The greateſt quantity of labour is devolved upon the neuters; but they are not, like the neuter bees, the only workers; for there is no part of their different operations which the females, at certain times, do not execute. Neither do the males, though their induſtry is not comparable to that of the

neuters,

neuters, remain entirely idle. They often occupy themſelves in the interior part of the neſt. The greateſt part of the labour, however, is performed by the neuters. They build the neſt, feed the males, the females, and even the young. But, while the neuters are employed in theſe different operations, the others are abroad in hunting parties. Some attack with intrepidity live inſects, which they ſometimes carry entire to the neſt; but they generally tranſport the abdomen or belly only. Others pillage butchers ſtalls, from which they often arrive with a piece of meat larger than the half of their own bodies. Others reſort to gardens, and ſuck the juices of fruits. When they return to the neſt, they diſtribute a part of their plunder to the females, to the males, and even to ſuch neuters as have been uſefully occupied at home. As ſoon as a neuter enters the neſt, it is ſurrounded by ſeveral waſps, to each of whom it freely gives a portion of the food it has brought. Thoſe who have not been hunting for prey, but have been ſucking the juices of fruits, though they ſeem to return empty, fail not to regale their companions; for, after their arrival, they ſtation themſelves upon the upper part of the neſt, and diſcharge from their mouths two or three drops of a clear liquid, which are immediately ſwallowed by the domeſtics.

The neuter waſps, though the moſt laborious, are the ſmalleſt; but they are extremely active and vivacious. The females are much larger, heavier, and ſlower in their movements. The males are of an intermediate ſize between that of the females and neuters. From theſe differences in ſize, it is eaſy to diſtinguiſh the different kinds of thoſe waſps which build their neſts below the ground. In the hive of the honey-bee, the number of females is always extremely ſmall; but, in a waſp's neſt, there are often more than three hundred females. During the months of June, July, and Auguſt, they remain conſtantly in the neſt, and are never ſeen abroad except in the beginning of ſpring, and in the months of September and October. During the ſummer, they are totally occupied in laying their eggs and feeding their young. In this

this laſt operation, they are aſſiſted by the other waſps; for the females alone, though numerous, would be inſufficient for the laborious taſk. A waſp's neſt, when completed, ſometimes conſiſts of ſixteen thouſand cells, each of which contains an egg, a worm, or a nymph. The eggs are white, tranſparent, of an oblong figure, and differ in ſize, according to the kind of waſps which are to proceed from them. Some of them are no larger than the head of a ſmall pin. They are ſo firmly glued to the bottoms of the cells, that it is with difficulty they can be detached without breaking. Eight days after the eggs are depoſited in the cells, the worms are hatched, and are conſiderably larger than the eggs which gave birth to them. Theſe worms demand the principal cares of the waſps who continue always in the neſt. They feed them, as birds feed their young, by giving them, from time to time, a mouthful of food. It is aſtoniſhing to ſee with what induſtry and rapidity a female runs along the cells of a comb, and diſtributes to each worm a portion of nutriment. In proportion to the ages and conditions of the worms, they are fed with ſolid food, ſuch as the bellies of inſects, or with a liquid ſubſtance diſgorged by the mother. When a worm is ſo large as to occupy its whole cell, it is then ready to be metamorphoſed into a nymph. It then refuſes all nouriſhment, and ceaſes to have any connection with the waſps in the neſt. It ſhuts up the mouth of its cell with a fine ſilken cover, in the ſame manner as the ſilk-worm and other caterpillars ſpin their cods. This operation is completed in three or four hours, and the animal remains in the nymph ſtate nine or ten days, when, with its teeth, it deſtroys the external cover of the cell, and comes forth in the form of a winged inſect, which is either male, female, or neuter, according to the nature of the egg from which it was hatched. In a ſhort time, the waſps newly transformed receive the food brought into the neſt by the foragers in the fields. What is ſtill more curious, in the courſe of the firſt day after their transformation, the young waſps have been obſerved going to the fields, bringing in proviſions, and diſtributing them to the worms in the cells.

A cell

A cell is no fooner abandoned by a young wafp, than it is cleaned, trimmed, and repaired by an old one, and rendered, in every refpect, proper for the reception of another egg.

As formerly mentioned, wafps of different fexes differ greatly in fize. The animals know how to conftruct cells proportioned to the dimenfions of the fly that is to proceed from the egg which the female depofits in them. The neuters are fix times fmaller than the females, and their cells are built nearly in the fame proportion. Cells are not only adapted for the reception of neuters, males, and females, but it is remarkable that the cells of the neuters are never intermixed with thofe of the males or females. A comb is entirely occupied with fmall cells fitted for the reception of neuter worms. But male and female cells are often found in the fame comb. The males and females are of equal length, and, of courfe, require cells of an equal deepnefs. But the cells of the males are narrower than thofe of the females, becaufe the bodies of the former are never fo thick as thofe of the latter.

This wonderful affemblage of combs, of the pillars which fupport them, and of the external envelope, is an edifice which requires feveral months labour, and ferves the animals one year only. This habitation, fo populous in fummer, is almoft deferted in winter, and abandoned entirely in fpring; for, in this laft feafon, not a fingle wafp is to be found in a neft of the preceding year. It is worthy of remark, that the firft combs of a neft are always accommodated for the reception of the neuter or working wafps. The city, of which the foundation has juft been laid, requires a number of workmen. The neuter or working wafps are accordingly firft produced. A cell is no fooner half-completed than an egg of a neuter is depofited in it by the female. Of fourteen or fifteen combs inclofed in a common cover, the four laft only are deftined for the reception of males and females. Hence it uniformly happens, that, before the males and females are capable of taking flight, every wafp's neft is peopled with feveral thoufand neuters or workers. But the neuters, who are firft produced, are likewife the firft that pe-

 rifh;

rifh; for not one of them furvives the termination even of a mild winter. It was remarked by the ancient Naturalifts, that fome wafps lived one year only, and others two. To the former Ariftotle gives the appellation of *operarii*, which are our workers or neuters, and to the latter *matrices*, which are our females.

The female wafps are ftronger, and fupport the rigours of winter better, than the males or neuters. Before the end of winter, however, feveral hundred females die, and not above ten or a dozen in each neft furvive that feafon. Thefe few females are deftined for the continuation of the fpecies. Each of them becomes the founder of a new republic. When a queen-bee departs from a hive, in order to eftablifh a new one, fhe is always accompanied with feveral thoufand induftrious labourers, ready to perform every neceffary operation. But the female wafp has not the aid of a fingle labourer; for all the neuters are dead before the beginning of the fpring. The female alone lays the foundation of a new republic. She either finds or digs a hole under the earth, builds cells for the reception of her eggs, and feeds the worms which proceed from them. Whenever any of thefe neuter worms are transformed into flies, they immediately affift their parent in augmenting the number of cells and combs, and in feeding the young worms, which are daily hatching from the eggs. In a word, this female wafp, which in fpring was perfectly folitary, without any proper habitation, and had every operation to perform, has, in autumn, feveral thoufands of her offspring at her devotion, and is furnifhed with a magnificent palace, or rather city, to protect her from the injuries of the weather and from external enemies.

With regard to the male wafps, it is uncertain whether any of them furvive the winter. But, though not fo indolent as the males of the honey-bee, they can be of little affiftance to the female; for they never engage in any work of importance, fuch as conftructing cells, or fortifying the external cover of the neft. They are never brought forth till towards the end of Auguft; and their fole occupation feems to be that of keeping the neft clean:

They

They carry out every kind of filth, and the carcases of such of their companions as happen to die. In performing this operation, two of them often join, and, as mentioned in another place, when the load is too heavy, they cut off the head, and transport the dead animal at two times.

In the beginning of spring, when the female wasp has built her subterraneous habitation, which is soon to be peopled with thousands of flies, she has no occasion for the males; because, in the month of September or October, she had been previously impregnated. The males and females are produced at the same time, and they are nearly equal in number. Like the male honey-bees, the male wasps are destitute of stings, but the females and neuters have stings, the poisonous liquor of which, when introduced into any part of the human body, excites inflammation, and creates a considerable degree of pain.

The habitations and the œconomy of the common *ant* are exceedingly curious. But, as they are so well known, and so obvious to inspection and examination, we shall not detain the reader with a description of them. To supply this defect, we shall give some account of the truly wonderful operations of the *termites*, which are generally called *white-ants* *, though they belong to a different genus of insects. These animals infest Guinea, and all the tropical regions, where, for their depredations of property, they are greatly dreaded by the inhabitants; from which circumstance they have received the name of *Fatalis*, or *Destructor*.

The following abridged account of the *termites*, and of the wonderful habitations they build, is selected from an excellent description of them in a Letter from Mr. Henry Smeathman, of Clement's Inn, to Sir Joseph Banks, which was published in the Philosophical Transactions †. Though the nests, or rather hills, constructed by the termites, are mentioned by many travellers, their descriptions and observations are by no means so accurate as those of the ingenious

* In the windward parts of Africa, they are denominated *bugga, buggs*; in the West-Indies, *wood-lice, wood-ants*, or *white-ants*. They are likewise called *piercers, eaters*, or *cutters*, because they cut almost every thing in pieces. S.

† Vol. 71. part. 1. page 139. S.

ingenious Mr. Smeathman. Of these insects there are several species; but they all resemble each other in form, and in their manner of living. They differ, however, as much as birds, in the stile of their architecture, and in the selection of the materials of which their nests are composed. Some build on the surface, or partly above and partly below the ground, and others on the trunks or branches of lofty trees.

Before describing the nests or hills, it is necessary to give some idea of the animals themselves, and of their general œconomy and manners. We shall confine ourselves to that species called *termites bellicosi*, or *fighters*, because they are largest, and best known on the coast of Africa.

The republic of the *termites bellicosi*, like the other species of this genus, consists of three ranks, or orders of insects: 1. The working insects, which Mr. Smeathman distinguishes by the name of *labourers*; 2. The fighters, or *soldiers*, which perform no kind of labour; and, 3. The winged, or *perfect insects*, which are male and female, and capable of multiplying the species. These last Mr. Smeathman calls the *nobility* or *gentry*; because they neither labour nor fight. The nobility alone are capable of being raised to the rank of kings and queens. A few weeks after their elevation to this state, they emigrate, in order to establish new empires.

In a nest or hill, the labourers, or working insects, are always most numerous: There are at least one hundred labourers to one of the fighting insects or soldiers. When in this state, they are about a fourth of an inch in length, which is rather smaller than some of our ants. From their figure, and fondness for wood, they are very generally known by the name of *wood-lice*.

The second order, or soldiers, differ in figure from that of the labourers. The former have been supposed to be neuters, and the latter males. But, in fact, they are the same insects. They have only undergone a change of form, and made a nearer approach to the perfect state. They are now much larger, being half an inch in length, and equal in size to fifteen of the labourers. The form of

of the head is likewiſe greatly changed. In the labourer ſtate, the mouth is evidently formed for gnawing or holding bodies: But, in the ſoldier ſtate, the jaws being ſhaped like two ſharp awls a little jagged, are deſtined ſolely for piercing or wounding. For theſe purpoſes they are very well calculated; for they are as hard as a crab's claw, and placed in a ſtrong horny head, which is of a nut-brown colour, and larger than the whole body.

The figure of the third order, or that of the inſect in its perfect ſtate, is ſtill more changed. The head, the thorax, and the abdomen, differ almoſt entirely from the ſame parts in the labourers and ſoldiers. Beſide, the animals are now furniſhed with four large, browniſh, tranſparent wings, by which they are enabled, at the proper ſeaſon, to emigrate and to eſtabliſh new ſettlements. In the winged or perfect ſtate, they have likewiſe acquired the organs of generation, and are greatly altered in their ſize as well as in their figure. Their bodies now meaſure between ſix and ſeven tenths of an inch, their wings, from tip to tip, above two inches and a half, and their bulk is equal to that of thirty labourers, or two ſoldiers. Inſtead of active, induſtrious, and rapacious little animals, when they arrive at their perfect ſtate, they become innocent, helpleſs, and daſtardly. Their numbers are great; but their enemies are ſtill more numerous. They are devoured by birds, by every ſpecies of ants, by carnivorous reptiles, and even by the inhabitants of many parts of Africa. This laſt fact is atteſted by Piſo, Margraave, De Laet, Konig, Moor, Sparman, and by many other travellers, as well as by Smeathman. After ſuch devaſtation, it is ſurpriſing that a ſingle pair ſhould eſcape ſo many dangers. 'Some, however,' ſays Mr. Smeathman, 'are ſo fortunate; and being found by ſome of the labouring inſects, that are continually running about the 'ſurface of the ground under their covered galleries, are '*elected Kings* and *Queens* of new ſtates; all thoſe who are 'not ſo elected and preſerved certainly periſh. The manner in which theſe labourers protect the happy pair from 'their innumerable enemies, not only on the day of the 'maſſacre of almoſt all their race, but for a long time 'after,

'after, will, I hope, juſtify me in the uſe of the term
'*election*. The little induſtrious creatures immediately
'incloſe them in a ſmall chamber of clay ſuitable to their
'ſize, into which, at firſt, they leave but one ſmall en-
'trance, large enough for themſelves and the ſoldiers to
'go in and out, but much too little for either of the
'royal pair to make uſe of; and when neceſſity obliges
'them to make more entrances, they are never larger;
'ſo that, of courſe, the *voluntary ſubjects* charge them-
'ſelves with the taſk of providing for the offspring of
'their ſovereigns, as well as to work and to fight for
'them, until they have raiſed a progeny capable at leaſt
'of dividing the taſk with them.

'It is not till this, probably, that they conſummate
'their marriage, as I never ſaw a pair of them joined.
'The buſineſs of propagation, however, ſoon commences;
'and the labourers having conſtructed a ſmall wooden nur-
'ſery, carry the eggs and lodge them there as faſt as they
'can obtain them from the *queen*.

'About this time a moſt extraordinary change begins
'to take place in the *queen*, to which I know nothing
'ſimilar, except in the *pulex penetrans* of Linnæus, the
'*jigger* of the Weſt-Indies, and in the different ſpecies
'of *coccus*, *cochineal*. The abdomen of this female begins
'gradually to extend and enlarge to ſuch an enormous
'ſize, that an *old queen* will have it increaſed ſo as to be
'*fifteen hundred* or *two thouſand times* the bulk of the reſt
'of her body, and *twenty* or *thirty thouſand times* the bulk
'of a labourer, as I have found by carefully weighing
'and computing the different ſtates. The ſkin between
'the ſegments of the abdomen extends in every direction;
'and at laſt the ſegments are removed to half an inch
'diſtance from each other, though, at firſt, the length of
'the whole abdomen is not half an inch. I conjecture
'the animal is upwards of two years old when the abdo-
'men is increaſed to three inches in length: I have ſome-
'times found them of near twice that ſize. The abdo-
'men is now of an irregular oblong ſhape, being con-
'tracted by the muſcles of every ſegment, and is become
'one vaſt matrix full of eggs, which make long circum-
'volutions

'volutions through an innumerable quantity of very 'minute veſſels that circulate round the inſide in a ſer-'pentine manner, which would exerciſe the ingenuity of 'a ſkilful anatomiſt to diſſect and develope. This ſingu-'lar matrix is not more remarkable for its amazing ex-'tenſion and ſize than for its periſtaltic motion, which 'reſembles the undulating of waves, and continues inceſ-'ſantly without any apparent effort of the animal; ſo 'that one part or other, alternately, is riſing and ſinking 'in perpetual ſucceſſion, and the matrix ſeems never at 'reſt, but is always protruding eggs to the amount (as I 'have frequently counted in old queens) of ſixty in a 'minute, or eighty thouſand and upward in one day of 'twenty-four hours.

'Theſe eggs are inſtantly taken from her body by her 'attendants, (of whom there always are, in the royal 'chamber and the galleries adjacent, a ſufficient number 'waiting), and carried to the nurſeries, which, in a great 'neſt, may ſome of them be four or five feet diſtant in 'a ſtraight line, and, conſequently, much farther by their 'winding galleries. Here, after they are hatched, the 'young are attended and provided with every thing 'neceſſary until they are able to ſhift for themſelves, and 'take their ſhare of the labours of the community.'

We ſhall now endeavour to give ſome idea of the almoſt incredible architecture and œconomy of theſe wonderful inſects.

The neſts of the *termites bellicoſi*, or wood-lice, are called *hills* by the natives of Africa, New Holland, and other hot climates. This appellation is highly proper; for they are often elevated ten or twelve feet above the ſurface of the earth, and are nearly of a conical figure. Theſe hills, inſtead of being rare phenomena, are ſo frequent in many places near Senegal, that, as deſcribed with great propriety by Monſ. Adanſon, their number, magnitude, and cloſeneſs of ſituation, make them appear like villages of the Negroes. 'But, of all the extraordinary things 'I obſerved,' ſays Monſ. Adanſon, 'nothing ſtruck me 'more than certain eminences, which, by their height 'and regularity, made me take them, at a diſtance, for 'an

'an aſſemblage of Negro huts, or a conſiderable village, 'and yet they were only the neſts of certain inſects. 'Theſe neſts are round pyramids, from eight to ten feet 'high, upon nearly the ſame baſe, with a ſmooth ſurface 'of rich clay, exceſſively hard and well built *.' Jobſon, in his hiſtory of Gambia, tells us, that "the ant-hills 'are remarkable caſt up in thoſe parts by piſmires, ſome 'of them twenty foot in height, of compaſſe to contayne 'a dozen of men, with the heat of the ſun baked into 'that hardneſſe, that we uſed to hide ourſelves in the 'ragged toppes of them, when we took up ſtands to ſhoot 'at deere or wild beaſts †.' Mr. Boſman remarks, in his deſcription of Guinea, that "the ants make neſts of the 'earth about twice the height of a man ‡.'

Each of theſe hills is compoſed of an exterior and an interior part. The exterior cover is a large clay-ſhell, which is ſhaped like a dome. Its ſtrength and magnitude are ſufficient to incloſe and protect the interior building from the injuries of the weather, and to defend its numerous inhabitants from the attacks of natural or accidental enemies. The external dome or cover is, therefore, always much ſtronger than the internal building, which is the habitation of the inſects, and is divided with wonderful artifice and regularity into a vaſt number of apartments for the reſidence and accommodation of the king and queen, for the nurſing of their progeny, and for magazines, which are always well ſtored with proviſions.

Theſe hills make their firſt appearance in the form of conical turrets, about a foot high. In a ſhort time, the inſects erect, at a little diſtance, other turrets, and go on increaſing their number and widening their baſes, till their underworks are covered with theſe turrets, which the animals always raiſe higheſt in the middle of the hill, and, by filling up the intervals between each turret, collect them, at laſt, into one great dome.

'The *royal chamber*,' Mr. Smeathman remarks, 'which 'is

* Adanſon's Voyage to Senegal, 8vo, pag. 153.—337. Voyage de Senegal. 4to, pag. 83.—99. S.

† Purchas's Pilgrams, vol. 2. pag. 1570. S.

‡ Page 276.—493. S.

'is occupied by the king and queen, appears to be, in 'the opinion of this little people, of the moſt conſequence, 'and is always ſituated as near the center of the interior 'building as poſſible, and generally about the height of 'the common ſurface of the ground. It is always nearly 'in the ſhape of half an egg, or an obtuſe oval, within, 'and may be ſuppoſed to repreſent a long oven. In the 'infant ſtate of the colony, it is not above an inch, or 'thereabouts, in length; but in time will be increaſed to 'ſix or eight inches, or more, in the clear, being always 'in proportion to the ſize of the queen, who, increaſing 'in bulk as in age, at length requires a chamber of ſuch 'dimenſions.'

The entrances into the royal chamber will not admit any animal larger than the ſoldiers or labourers. Hence the *king* and the *queen*, which laſt, when full grown, is a thouſand times the weight of a king, can never poſſibly go out. The royal chamber is ſurrounded by an innumerable quantity of others, which are of different ſizes, figures, and dimenſions; but all of them are arched either in a circular or an elliptical form. Theſe chambers either open into each other, or have communicating paſſages, which, being always clear, are evidently intended for the conveniency of the ſoldiers and attendants, of whom, as will ſoon appear, great numbers are neceſſary. Theſe apartments are joined by the magazines and nurſeries. The magazines are chambers of clay, and are at all times well ſtored with proviſions, which, to the naked eye, ſeem to conſiſt of the raſpings of wood and plants which the termites deſtroy; but, when examined by the microſcope, they are found to conſiſt chiefly of the gums or inſpiſſated juices of plants, thrown together in ſmall irregular maſſes. Of theſe maſſes, ſome are finer than others, and reſemble the ſugar about preſerved fruits; others reſemble the tears of gum, one being quite tranſparent, another like amber, a third brown, and a fourth perfectly opaque.

The magazines are always intermixed with the nurſeries, which laſt are buildings totally different from the reſt of the apartments. They are compoſed entirely of wooden

materials, which ſeem to be cemented with gums. Mr. Smeathman very properly gives them the appellation of *nurſeries;* becauſe they are invariably occupied by the eggs, and the young ones, which firſt appear in the ſhape of labourers; but they are as white as ſnow. Theſe buildings are exceedingly compact, and are divided into a number of ſmall irregular-ſhaped chambers, not one of which is half an inch wide. They are placed all round, and as near as poſſible to the royal apartments.

When a neſt or hillock is in the infant ſtate, the nurſeries are cloſe to the royal apartment. But as, in proceſs of time, the body of the queen enlarges, it becomes neceſſary, for her accommodation, to augment the dimenſions of her chamber. She then, likewiſe, lays a greater number of eggs, and requires more attendants; of courſe, it is neceſſary that both the number and dimenſions of the adjacent apartments ſhould be augmented. For this purpoſe, the ſmall firſt-built nurſeries are taken to pieces, rebuilt a little farther off, made a ſize larger, and their number, at the ſame time, is increaſed. Thus the animals are continually employed in pulling down, repairing, or rebuilding their apartments; and theſe operations they perform with wonderful ſagacity, regularity, and foreſight.

One remarkable circumſtance regarding the nurſeries muſt not be omitted. They are always ſlightly overgrown with a kind of *mould*, and plentifully ſprinkled with white globules about the ſize of a ſmall pin's head. Theſe globules, Mr. Smeathman at firſt conjectured to be the eggs; but, when examined by the microſcope, they evidently appeared to be a ſpecies of muſhroom, in ſhape reſembling our eatable muſhroom when young. When entire, they are white like ſnow a little melted and frozen again; and, when bruiſed, they ſeem to be compoſed of an infinite number of pellucid particles, approaching to oval forms, and are with difficulty ſeparated from each other. The mouldineſs ſeems likewiſe to conſiſt of the ſame kind of ſubſtance *.

The

* Mr. Konig, who examined the termites neſts in the Eaſt-Indies, conjectures, that theſe muſhrooms are the food of the young inſects. This ſuppoſition implies, that

The nurferies are inclofed in chambers of clay, like thofe which contain the provifions ; but they are much larger. In the early ftate of the neft, they are not bigger than an hazel nut; but, in great hills, they are often as large as a child's head of a year old.

The *royal chamber* is fituated nearly on a level with the furface of the ground, at an equal diftance from all the fides of the building, and directly under the apex of the hill. On all fides, both above and below, it is furrounded by what are called the *royal apartments*, which contain only labourers and foldiers, who can be intended for no other purpofe than to continue in the neft either to guard or ferve their common *father* and *mother*, on whofe fafety the happinefs, and, in the eftimation of the Negroes, the exiftence, of the whole community depends. Thefe apartments compofe an intricate labyrinth, which extends a foot or more in diameter from the royal chamber on every fide. Here the nurferies and magazines of provifions begin; and, being feparated by fmall empty chambers and galleries, which furround them, and communicate with each other, are continued on all fides to the outward fhell, and reach up within it two-thirds or three-fourths of its height, leaving an open area in the middle under the dome, which refembles the nave of an old cathedral. This area is furrounded by large Gothic arches, which are fometimes two or three feet high next the front of the area, but diminifh rapidly as they recede, like the arches of aifles in perfpectives, and are foon loft among the innumerable chambers and nurferies behind them. All thefe chambers and paffages are arched, and contribute mutually to fupport one another. The interior building, or affemblage of nurferies, chambers, and paffages, has a flattifh roof, without any perforation. By this contrivance, if, by accident, water fhould penetrate the external dome, the apartments below are preferved from injury. The area has alfo a flattifh floor, which is fituated above the

that the old ones have a method of providing for and promoting the growth of the mufhroom ; 'a circumftance,' Mr. Smeathman remarks, 'which, however 'ftrange to thofe unacquainted with the fagacity of thofe infects, I will venture 'to fay, from many other extraordinary facts I have feen of them, is not very 'improbable.' S.

the royal chamber. It is likewiſe water-proof, and ſo conſtructed, that, if water gets admittance, it runs off by ſubterraneous paſſages, which are of an aſtoniſhing magnitude. ‘ I meaſured one of them,’ ſays Mr. Smeathman, ‘ which was perfectly cylindrical, and thirteen inches in ‘ diameter.’ Theſe ſubterraneous paſſages are thickly lined with the ſame kind of clay of which the hill is compoſed, aſcend the internal part of the external ſhell in a ſpiral form, and, winding round the whole building up to the top, interſect and communicate with each other at different heights. From every part of theſe large galleries a number of pipes, or ſmaller galleries, leading to different parts of the building, proceed. There are likewiſe a great many which lead downward, by ſloping deſcents, three and four feet perpendicular under ground, among the gravel, from which the labouring termites ſelect the finer parts, which, after being worked up in their mouths to the conſiſtence of mortar, become that ſolid clay or ſtone of which their hills, and every apartment of their buildings, except the nurſeries, are compoſed. Other galleries aſcend and lead out horizontally on every ſide, and are carried under ground, but near the ſurface, to great diſtances. Suppoſe the whole neſts within a hundred yards of a houſe were completely deſtroyed, the inhabitants of thoſe at a greater diſtance will carry on their ſubterraneous galleries, and invade the goods and merchandizes contained in it by ſap and mine, unleſs great attention and circumſpection are employed by the proprietor.

Mr. Smeathman concludes his deſcription of the habitations of the *termites bellicoſi*, with much modeſty, in the following words: ‘ Thus I have deſcribed, as briefly as ‘ the ſubject would admit, and I truſt without exaggera- ‘ ration, thoſe wonderful buildings, whoſe ſize, and ex- ‘ ternal form, have often been mentioned by travellers, ‘ but whoſe interior, and moſt curious parts are ſo little ‘ known, that I may venture to conſider my account of ‘ them as new, which is the only merit it has; for they ‘ are conſtructed upon ſo different a plan from any thing ‘ elſe upon the earth, and ſo complicated, that I cannot ‘ find words equal to the taſk.’

When

When a breach is made in one of the hills by an ax, or other inſtrument, the firſt object that attracts attention is the behaviour of the ſoldiers, or fighting inſects. Immediately after the blow is given, a ſoldier comes out, walks about the breach, and ſeems to examine the nature of the enemy, or the cauſe of the attack. He then goes in to the hill, gives the alarm, and, in a ſhort time, large bodies ruſh out as faſt as the breach will permit. It is not eaſy to deſcribe the fury theſe fighting inſects diſcover. In their eagerneſs to repel the enemy, they frequently tumble down the ſides of the hill, but recover themſelves very quickly, and bite every thing they encounter. This biting, joined to the ſtriking of their forceps upon the building, makes a crackling or vibrating noiſe, which is ſomewhat ſhriller and quicker than the ticking of a watch, and may be heard at the diſtance of three or four feet. While the attack proceeds, they are in the moſt violent buſtle and agitation. If they get hold of any part of a man's body, they inſtantly make a wound, which diſcharges as much blood as is equal to their own weight. When they attack the leg, the ſtain of blood upon the ſtocking extends more than an inch in width. They make their hooked jaws meet at the firſt ſtroke, and never quit their hold, but ſuffer themſelves to be pulled away leg by leg, and piece after piece, without the ſmalleſt attempt to eſcape. On the other hand, if a perſon keeps out of their reach, and gives them no farther diſturbance, in leſs than half an hour they retire into the neſt, as if they ſuppoſed the wonderful monſter that damaged their caſtle had fled. Before the whole ſoldiers have got in, the labouring inſects are all in motion, and haſten toward the breach, each of them having a quantity of tempered mortar in his mouth. This mortar they ſtick upon the breach as faſt as they arrive, and perform the operation with ſo much diſpatch and facility, that, notwithſtanding the immenſity of their numbers, they never ſtop or embarraſs one another. During this ſcene of apparent hurry and confuſion, the ſpectator is agreeably ſurpriſed when he perceives a regular wall gradually ariſing and filling up the chaſm. While the labourers are thus employed, almoſt

almoſt all the ſoldiers remain within, except here and there one, who ſaunters about among ſix hundred or a thouſand labourers, but never touches the mortar. One ſoldier, however, always takes his ſtation cloſe to the wall that the labourers are building. This ſoldier turns himſelf leiſurely on all ſides, and, at intervals of a minute or two, raiſes his head, beats upon the building with his forceps, and makes the vibrating noiſe formerly mentioned. A loud hiſs inſtantly iſſues from the inſide of the dome and all the ſubterraneous caverns and paſſages. That this hiſs proceeds from the labourers is apparent; for, at every ſignal of this kind, they work with redoubled quickneſs and alacrity. A renewal of the attack, however, inſtantly changes the ſcene. ' On the firſt ' ſtroke,' Mr. Smeathman remarks, ' the labourers run ' into the many pipes and galleries with which the build- ' ing is perforated, which they do ſo quickly, that they ' ſeem to vaniſh; for in a few ſeconds all are gone, and ' the ſoldiers ruſh out as numerous and as vindictive as ' before. On finding no enemy, they return again leiſurely ' into the hill, and, very ſoon after, the labourers appear ' loaded as at firſt, as active, and as ſedulous, with ſol- ' diers here and there among them, who act juſt in the ' ſame manner, one or other of them giving the ſignal ' to haſten the buſineſs. Thus the pleaſure of ſeeing them ' come out to fight or to work, alternately, may be ob- ' tained as often as curioſity excites, or time permits; ' and it will certainly be found, that the one order never ' attempts to fight, or the other to work, let the emer- ' gency be ever ſo great.'

It is exceedingly difficult to explore the interior parts of a neſt or hill. The apartments which ſurround the royal chamber and the nurſeries, and indeed the whole fabrick, have ſuch a dependence on each other, that the breaking of one arch generally pulls down two or three. There is another great obſtacle to our reſearches, namely, the obſtinacy of the ſoldiers, who, ſays our author, ' fight ' to the very laſt, diſputing every inch of ground ſo well ' as often to drive away the Negroes who are without ' ſhoes, and make white people bleed plentifully through

' their

'their ſtockings. Neither can we let a building ſtand ſo
'as to get a view of the interior parts without interrup-
'tion; for, while the ſoldiers are defending the outworks,
'the labourers keep barricading all the way againſt us,
'ſtopping up the different galleries and paſſages which
'lead to the various apartments, particularly the royal
'chamber, all the entrances to which they fill up ſo art-
'fully as not to let it be diſtinguiſhable while it remains
'moiſt; and, externally, it has no other appearance than
'that of a ſhapeleſs lump of clay. It is, however, eaſily
'found from its ſituation with reſpect to the other parts
'of the building, and by the crowds of labourers and
'ſoldiers which ſurround it, who ſhow their loyalty and
'fidelity by dying under its walls. The royal chamber,
'in a large neſt, is capacious enough to hold many hun-
'dreds of the attendants, beſides the royal pair; and you
'always find it as full of them as it can hold. Theſe
'faithful ſubjects never abandon their charge even in the
'laſt diſtreſs; for, whenever I took out the royal cham-
'ber, and as I often did, preſerved it in a large glaſs
'bowl, all the attendants continued running in one di-
'rection round the king and queen with the utmoſt ſo-
'licitude, ſome of them ſtopping at the head of the latter,
'as if to give her ſomething. When they came to the
'extremity of the abdomen, they took the eggs from her,
'and carried them away, and piled them carefully together
'in ſome part of the chamber, or in the bowl under, or
'behind any pieces of broken clay which lay moſt con-
'venient for the purpoſe.'

In this chapter, I have given a ſuccinct view of the ſagacity, dexterity, and architectonic powers, exhibited in the conſtruction of habitations by the different claſſes of animals. But I am not without apprehenſions, that, in my endeavours to avoid prolixity, I may have, in ſome inſtances, degenerated into obſcurity. Enough, however, I hope, has been ſaid, either for the purpoſes of admiration or of reaſoning; and, therefore, I ſhall not anticipate the reflections of my readers, but proceed to the next ſubject.

CHAP.

CHAPTER XIV.

Of the Hoſtilities of Animals.

IN contemplating the ſyſtem of animation exhibited in this planet, the only one of which we have any extenſive knowledge, the mind is ſtruck, and even confounded, with the general ſcene of havock and devaſtation which is perpetually, and every where, preſented to our view. There is not, perhaps, a ſingle ſpecies of animated beings, whoſe exiſtence depends not, more or leſs, upon the death and deſtruction of others. Every animal, when not prematurely deprived of life by thoſe who are hoſtile to it, or by accident, enjoys a temporary exiſtence, the duration of which is longer or ſhorter according to its nature, and the rank it holds in the creation; and this exiſtence univerſally terminates in death and diſſolution. This is an eſtabliſhed law of Nature, to which every animal is obliged to ſubmit. But this neceſſary and univerſal deprivation of individual life, though great, is nothing when compared to the havock occaſioned by another law, which impels animals to kill and devour different ſpecies, and ſometimes their own. In the ſyſtem of Nature, death and diſſolution ſeem to be indiſpenſible for the ſupport and continuation of animal life.

But, though almoſt every animal, in ſome meaſure, depends for its exiſtence on the deſtruction of others, there are ſome ſpecies in all the different tribes or claſſes, which are diſtinguiſhed by the appellation of *carnivorous*, or *rapacious*, becauſe they live chiefly, or entirely, on animal food. In the proſecution of this ſubject, therefore, we ſhall, in the *firſt* place, mention ſome examples of animal hoſtility and rapacity; and, in the *next* place, endeavour to point out ſuch advantages as reſult from this apparently,

apparently-cruel inſtitution of Nature. On the laſt branch of the ſubject, however, the reader muſt not expect to have every difficulty removed, and every queſtion ſolved. Like all the other parts of the œconomy of Nature, the neceſſity, or even the ſeeming cruelty and injuſtice, of allowing animals to prey upon one another, is a myſtery which we can never be enabled completely to unravel. But we are not entirely without hopes of ſhowing ſeveral important utilities which reſult from this almoſt univerſal ſcene of animal devaſtation.

Of all rapacious animals, *Man* is the moſt univerſal deſtroyer. The deſtruction of carnivorous quadrupeds, birds, and inſects, is, in general, limited to particular kinds. But the rapacity of man has hardly any limitation. His empire over the other animals which inhabit this globe is almoſt univerſal. He accordingly employs his power, and ſubdues or devours every ſpecies. Of ſome of the quadruped tribes, as the horſe, the dog, the cat, he makes domeſtic ſlaves; and though in this country, none of theſe ſpecies is uſed for food, he either obliges them to labour for him, or keeps them as ſources of pleaſure and amuſement. From other quadrupeds, as the ox, the ſheep, the goat, and the deer kind, he derives innumerable advantages. The ox kind in particular, after receiving the emoluments of their labour and fertility, he rewards with death, and then feeds upon their carcaſes. Many other ſpecies, though not commonly uſed as food, are daily maſſacred in millions for the purpoſes of commerce, luxury, and caprice. Myriads of quadrupeds are annually deſtroyed for the ſake of their furs, their hides, their tuſks, their odoriferous ſecretions, &c.

Over the feathered tribes the dominion of man is not leſs extenſive. There is not a ſingle ſpecies in the numerous and diverſified claſs of birds, which he either does not, or may not, employ for the nouriſhment of his body. By his ſagacity and addreſs he has been enabled to domeſticate many of the more prolific and delicious ſpecies, as turkies, geeſe, and the various kinds of poultry. Theſe he multiplies without end, and devours at pleaſure.

Neither do the inhabitants of the waters escape the rapacity of man. Rivers, lakes, and even the ocean itself, feel the power of his empire, and are forced to supply him with provisions. Neither air nor water can defend against the ingenuity, the art, and the destructive industry of the human species. Man may be said even to have domesticated some fishes. In artificial ponds, he feeds and rears carp, tench, perch, trout, and other species, and with them occasionally furnishes his table.

It might have been expected, that insects and reptiles, some of which have a most disgusting aspect, would not have excited the human appetite. But we learn from experience, that, in every region of the earth, many insects which inhabit both the earth and the waters, are esteemed as delicate articles of luxury. Even the viper, though its venom be deleterious, escapes not the all-devouring jaws of man.

Thus man holds, and too often exercises, a tyrannical dominion over almost the whole brute creation, not because he is the strongest of all animals, but because his intellect, though of a similar nature, is vastly superior to that of the most sagacious of the less favoured tribes. He reigns over the other animals, because, like them, he is not only endowed with sentiment, but because the powers of his mind are more extensive. He overcomes force by ingenuity, and swiftness by art and persevering industry. But the empire of man over the brute creation is not absolute. Some species elude his power by the rapidity of their flight, by the swiftness of their course, by the obscurity of their retreats, and by the element in which they live. Others escape him by the minuteness of their bodies; and, instead of acknowledging their sovereign, others boldly attack him with open hostility. He is also insulted and injured by the stings of insects, and by the poisonous bites of serpents. In other respects, man's empire, though comparatively great, is very much limited. He has no influence on the universe, on the motions and affections of the heavenly bodies, or on the revolutions of the globe which he inhabits. Neither has he a general dominion over animals, vegetables, or minerals.

nerals. His power reaches not ſpecies, but is confined to individuals. Every order of being moves on in its courſe, periſhes, or is renewed, by the irreſiſtible power of Nature. Even man himſelf, hurried along by the general torrent of time and of Nature, cannot prolong his exiſtence. He is obliged to ſubmit to the univerſal law; and, like all other organized beings, he is born, grows to maturity, and dies. Though man has been enabled to ſubdue the animal creation by the ſuperior powers of his mind, his empire, like all other empires, could not be firmly eſtabliſhed previous to the inſtitution of pretty numerous ſocieties. Almoſt the whole of his power is derived from ſociety. It matures his reaſon, gives exertion to his genius, and unites his forces. Before the formation of large ſocieties, man was perhaps the moſt helpleſs and the leaſt formidable of all animals. Naked, and deſtitute of arms, to him the earth was only an immenſe deſart peopled with ſtrong and rapacious monſters, by whom he was often devoured. Even long after this period, hiſtory informs us, that the firſt heroes were deſtroyers of wild beaſts. But, after the human ſpecies had multiplied, and ſpread over the earth, and when, by means of ſociety and the arts, man was enabled to conquer a conſiderable part of the globe, he forced the wild beaſts gradually to retire to the deſarts. He cleared the earth of thoſe gigantic animals who, perhaps, now no longer exiſt, but whoſe enormous bones are ſtill found in different regions, and are preſerved in the cabinets of the curious. He reduced the numbers of the voracious and noxious ſpecies. He oppoſed the powers and the dexterity of one animal to thoſe of another. Some he ſubdued by addreſs, and others by force. In this manner he, in proceſs of time, acquired to himſelf perfect ſecurity, and eſtabliſhed an empire that has no other limits than inacceſſible ſolitudes, burning ſands, frozen mountains, or obſcure caverns, which are occupied as retreats by a few ſpecies of ferocious animals.

Next to *man*, the carnivorous *quadrupeds* are the moſt numerous and the moſt deſtructive. Different parts of the earth are infeſted with lions, tigers, panthers, ounces, leopards,

leopards, jaguars, couguars, lynxes, wild cats, dogs, jackals, wolves, foxes, hyænas, civets, genets, polecats, martins, ferrets, ermines, gluttons, bats, &c. Though all theſe, and many other tribes of quadrupeds, live ſolely upon blood and carnage, yet ſome of them, as the tiger, the wolf, the hyæna, and many other inferior ſpecies, are much more rapacious and deſtructive than others. The lion, though ſurrounded with prey, kills no more than he is able to conſume. But the tiger is groſsly ferocious, and cruel without neceſſity. Though ſatiated with carnage, he perpetually thirſts for blood. His reſtleſs fury has no intervals, except when he is obliged to lie in ambuſh for prey at the ſides of lakes or rivers, to which other animals reſort for drink. He ſeizes and tears in pieces a freſh animal with equal rage as he exerted in devouring the firſt. He deſolates every country that he inhabits, and dreads neither the aſpect nor the arms of man. He ſacrifices whole flocks of domeſtic animals, and all the wild beaſts which come within the reach of his terrible claws. He attacks the young of the elephant and rhinoceros, and ſometimes even ventures to brave the lion. His predominant inſtinct is a perpetual rage, a blind and undiſtinguiſhing ferocity, which often impel him to devour his own young, and to tear their mother in pieces when ſhe attempts to defend them. He delights in blood, and gluts himſelf with it till he is intoxicated. He tears the body for no other purpoſe than to plunge his head into it, and to drink large draughts of blood, the ſources of which are generally exhauſted before his thirſt is appeaſed. The tiger is perhaps the only animal whoſe ferocity is unconquerable. Neither violence, reſtraint, nor bribery, have any effect in ſoftening his temper. With harſh or gentle treatment he is equally irritated. The mild and conciliating influence of ſociety makes no impreſſion on the obduracy and incorrigibleneſs of his diſpoſition. Time, inſtead of ſoftening the ferociouſneſs of his nature, only exaſperates his rage. He tears, with equal wrath, the hand which feeds him, as that which is raiſed to ſtrike him. He roars and grins at the ſight of every living being. Every animated object he regards

as a fresh prey, which he devours before hand with the avidity of his eyes, menaces it with frightful groans, and often springs at it, without regarding his chains, which only restrain, but cannot calm his fury.

In temperate climates, the wolf seems to exceed all other animals in the ferocity and rapaciousness of his disposition. When pressed with hunger, he braves every danger. He attacks all those animals which are under the protection of man, especially such as he can carry off with ease, as lambs, kids, and the smaller kinds of dogs. When successful in his expeditions, he returns often to the charge, till, after being chaced and wounded by men and dogs, he retires, during the day, to his den. In the night he again issues forth, traverses the country, roams round the cottages, kills all the animals that have been left without, digs the earth under the doors, enters with a terrible ferocity, and puts every living creature to death, before he chooses to depart, and carry off his prey. When these inroads happen to be fruitless, he returns to the woods, searches about with avidity, follows the track and the scent of wild beasts, and pursues them till they fall a prey to his rapacity. In a word, when his hunger is extreme, he loses all idea of fear, attacks women and children, and sometimes men; at last he becomes perfectly furious by excessive exertions, and generally falls a sacrifice to pure rage and distraction. When several wolves appear together, it is not an association of peace, but of war. It is attended with tumult and dreadful growlings, and indicates an attack upon some of the larger animals, as a stag, an ox, or a formidable mastiff. This depredatory expedition is no sooner ended than they separate, and every individual returns in silence to his solitude. Wolves are fond of human flesh. They have been known to follow armies, to come in troops to the field of battle, where bodies are carelessly interred, to tear them up, and to devour them with an insatiable avidity: And, when once accustomed to human flesh, these wolves ever after attack men, prefer the shepherd to the flock, devour women, and carry off children. Whole countries are sometimes obliged to arm, in order to destroy

ſtroy the wolves. It is a fortunate circumſtance that theſe dangerous and deſtructive animals have been long totally extirpated from Great-Britain and her iſlands.

Neither are the *feathered tribes* exempted from the general law of devaſtation. But the number of birds of prey, properly ſo called, is much leſs in proportion than that of carnivorous quadrupeds. Birds of prey are likewiſe weaker; and, of courſe, the deſtruction of animal life they occaſion is much more limited than the immenſe devaſtations daily committed by rapacious quadrupeds. But, as if tyranny never loſt ſight of its rights, great numbers of birds make prodigious depredations upon the inhabitants of the waters. A vaſt tribe of birds frequent the waters, and live ſolely upon fiſhes. In a certain ſenſe, every ſpecies of bird may be ſaid to be a bird of prey; for almoſt the whole of them devour flies, worms, and other inſects, either for food to themſelves or their young. Birds of prey, like carnivorous quadrupeds, are not ſo prolific as the milder and more inoffenſive kinds. Moſt of them lay only a ſmall number of eggs. The great eagle and the oſprey produce only two eggs in a ſeaſon. The pigeon, it may be ſaid, lays no more. But it ſhould be conſidered, that the pigeon produces two eggs three, four, or five times, from ſpring to autumn. All birds of prey exhibit an obduracy and a ferocioufneſs of diſpoſition, while the other kinds are mild, chearful, and gentle, in their aſpect and manners. Moſt birds of prey expel their offspring from the neſt, and relinquiſh them to their fate, before they are ſufficiently able to provide for themſelves. This cruelty is the effect of perſonal want in the mother. When prey is ſcanty, which often happens, ſhe in a manner ſtarves herſelf to ſupport her young. But, when her hunger becomes exceſſive, ſhe forgets her parental affection, ſtrikes, expels, and ſometimes, in a paroxyſm of fury produced by want, kills her offspring. An averſion to ſociety is another effect of this natural and acquired obduracy of temper. Birds of prey, as well as carnivorous quadrupeds, never aſſociate. Like robbers, they lead a ſolitary and wandering life. Mutual attachment unites the male and the female; and, as they are both

both capable of providing for themſelves, and can give mutual aſſiſtance in making war againſt other animals, they never ſeparate, even after the ſeaſon of love. The ſame pair are uniformly found in the ſame place; but they never aſſemble in flocks, nor even aſſociate in families. The larger kinds, as the eagles, require a greater quantity of food, and, for that reaſon, never allow their own offspring, after they have become rivals, to approach the places which the parents frequent. But all thoſe birds, and all thoſe quadrupeds, which are nouriſhed by the productions of the earth, live in families, are fond of ſociety, and aſſemble in numerous flocks, without quarrelling or diſturbing one another.

Both the earth and the air furniſh examples of rapacious animals. In theſe elements, however, the number of carnivorous animals is comparatively ſmall. But every inhabitant of the *waters* depends for its exiſtence upon rapine and deſtruction. The life of every *fiſh*, from the ſmalleſt to the greateſt, is one continued ſcene of hoſtility, violence, and evaſion. Their appetite for food is almoſt inſatiable. It impels them to encounter every danger. They are in continual motion; and the object of all their movements is to devour other fiſhes, or to avoid their own deſtruction. Their deſire for food is ſo keen and undiſtinguiſhing, that they greedily ſwallow every thing which has the appearance of animation. Thoſe that have ſmall mouths feed upon worms and the ſpawn of other fiſhes; and thoſe whoſe mouths are larger devour every animal, their own ſpecies not excepted, that can paſs through their gullet. To avoid deſtruction, the ſmaller fry retire to the ſhallows, where the larger kinds are unable to purſue them. But, in the watery element, no ſituation is abſolutely ſafe; for, even in the ſhallows, the oyſter, the ſcallop, and the muſcle, lie in ambuſh at the bottom, with their ſhells open, and, when a ſmall fiſh comes into contact with them, they inſtantly cloſe their ſhells upon him, and devour at leiſure their impriſoned prey. Neither is the hunting or purſuit of fiſhes confined to particular regions. Shoals of one ſpecies follow, with unwearied ardour, thoſe of another through vaſt

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tracts of the ocean. The cod purſues the whiting from the banks of Newfoundland to the ſouthern coaſts of Spain.

It is a remarkable circumſtance in the hiſtory of animated Nature, that carnivorous birds and quadrupeds are leſs prolific than the inoffenſive and aſſociating kinds; but, on the contrary, that the inhabitants of the waters, who are all carnivorous, are endowed with a moſt aſtoniſhing fecundity. All kinds of fiſhes, a few only excepted, are oviparous. Notwithſtanding the amazing deſtruction of their eggs by the ſmaller fry that frequent the ſhores, by aquatic birds, and by the larger fiſhes, the numbers which eſcape are ſufficient to ſupply the ocean with inhabitants, and to afford nouriſhment to a very great portion of the human race. A cod, for inſtance, according to the accurate computation of Lewenhoeck, produces, from one roe, above nine millions of eggs in a ſingle ſeaſon. The flounder lays annually above one million, and the mackarel more than five hundred thouſand: An increaſe ſo great, if permitted to arrive at maturity, that the ocean itſelf, in a few centuries, would not be ſpacious enough to contain its animated productions. This wonderful fertility anſwers two valuable purpoſes. In the midſt of numberleſs enemies it continues the reſpective ſpecies, and furniſhes to all a proper quantity of nouriſhment.

We have thus ſeen that man, ſome quadrupeds, ſome birds, and all fiſhes, are carnivorous animals. But this ſyſtem of carnage deſcends ſtill lower. Many of the *inſect* tribes derive their nouriſhment from putrid carcaſes, from the bodies of living animals, or from killing and devouring weaker ſpecies. How many flies are daily ſacrificed by ſpiders, a moſt voracious and a moſt numerous tribe of inſects? In return, ſpiders are greedily devoured by flies which are diſtinguiſhed by the name of *ichneumons*. The number of theſe ichneumon flies is inconceivable; and, if it were not for the prodigious havock they make upon caterpillars and other inſects, the fruits of the earth would be entirely deſtroyed. Waſps are extremely fond of animal food. They frequent butchers ſtalls, and beat

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off the flesh-fly, and every other insect that resorts thither for the purpose of depositing its eggs in the meat. Butchers take the advantage of this jealous warfare. They encourage the wasps, and make centinels of them, by giving them livers, which they prefer to more fibrous flesh, probably because they can cut livers more easily with their teeth.

The libella, dragon, or lady-fly, is well known by the beauty of its colours and the symmetry of its form. For these external qualities it has received the appellation of *lady-fly*. Its dispositions and its mode of life, however, are more ferocious and warlike than those of the Amazones. Like birds of prey, they hover about in the air, for the sole purpose of devouring almost every species of winged insect. They, accordingly, frequent marshy grounds, pools of water, and the margins of rivers, where insects most abound. Their appetite is so gross and voracious, that they not only devour small flies, but even the large flesh-fly, moths, and butterflies, of every kind.

It has been often said, that no animal spontaneously feeds upon its own species. This remark has probably been intended as an apology for, or at least a limitation to, the general system of carnage established by Nature. But, the observation, whatever might have been its intention, is unhappily a result of ignorance; for some quadrupeds, all fishes, and many insects, make no such discrimination. The weaker are uniformly preyed upon by the stronger. Reaumur put twenty of those caterpillars which feed upon the leaves of the oak into a vial. Though he regularly supplied them with plenty of fresh oak leaves, he observed that the number of dead ones daily increased. Upon a more attentive examination into the cause of this mortality, he found, that the stronger attacked with their teeth, killed, sucked out the vitals of their weaker companions, and left nothing but the head, feet, and empty skins. In a few days, one only of the twenty remained in life.

Caterpillars have myriads of external enemies, as birds of almost every kind, many of the smaller quadrupeds, their own species, and numberless insects. But this vast

fource of devaftation is ftill augmented by what may be denominated their internal enemies. Many flies depofit their eggs in the bodies of caterpillars. From thefe eggs proceed fmall maggots, which gradually devour the vitals of the animal in which they refide. When about to be transformed into chryfalids, they pierce the fkin of the caterpillar, fpin their pods, and remain on the empty fkin till they affume the form of flies, and efcape into the air to perform the fame cruel office to another unfortunate reptile. Every perfon muft recollect to have feen the colewort or cabbage caterpillar ftuck upon old walls, or the windows of country cottages, totally covered with thefe chryfalids, which have the form of fmall maggots, and are of a fine yellow colour. One of the moft formidable enemies of the caterpillar is a black worm, with fix cruftaceous legs. It is as long, and thicker than an ordinary fized caterpillar. In the fore part of the head it has two curved pincers, with which it quickly pierces the belly of a caterpillar, and never quits the prey till it is entirely devoured. The largeft caterpillar is not fufficient to nourifh this worm for a fingle day; for it daily kills and eats feveral of them. Thefe gluttonous worms, when gorged with food, become inactive, and almoft motionlefs. When in this fatiated condition, young worms of the fame fpecies attack and devour them. Of all trees, the oak, perhaps, nourifhes the greateft number of different caterpillars, as well as of different infects. Amongft others, the oak is inhabited by a large and beautiful beetle. This beetle frequents the oak, probably becaufe that tree is inhabited by the greateft number of caterpillars. It marches from branch to branch, and, when difpofed for food, attacks and devours the firft caterpillar that comes in its way.

The pucerons, vine-fretters, or plant-lice, are very injurious to trees and vegetables of almoft every kind. Their fpecies are fo numerous, and all of them are endowed with fuch a wonderful fertility, that we fhould expect to fee the leaves, the branches, and the ftems of every plant totally covered with them. But this aftonifhing fecundity, and the devaftation thefe fmall infects would unavoidably

unavoidably produce among the vegetable tribes, is checked by numberleſs enemies. Myriads of inſects of different claſſes, of different genera, and of different ſpecies, ſeem to be produced for no other purpoſe but to devour the pucerons. Some of theſe inſects are ſo voracious, that, notwithſtanding the extreme prolific powers of the pucerons, we have reaſon to be ſurpriſed that their ſpecies are not entirely annihilated. On every leaf inhabited by the puceron we find worms of different kinds. Theſe worms feed not upon the leaves, but upon the pucerons, whom they devour with an almoſt incredible rapacity. Some of theſe worms are transformed into flies with two wings, others into flies with four wings, and others into beetles. While in the worm-ſtate, one of theſe gluttonous inſects will ſuck out the vitals of twenty pucerons in a quarter of an hour. Reaumur ſupplied a ſingle worm with more than a hundred pucerons, every one of which it devoured in leſs than three hours.

Beſide the general ſyſtem of carnage produced by the neceſſity of one animal's feeding upon another, there are other ſources of deſtruction, which originate from very different motives. Man is not the only animal who wages war with his own ſpecies. War among mankind, in certain accidental ſituations of ſociety, may be productive, to particular nations or communities, of beneficial effects. But every advantage derived by war to one nation is acquired at the expence, and either the partial or the total ruin, of another. If univerſal peace could be completely eſtabliſhed, and if the earth were cultivated to the higheſt perfection, it is not probable that the multiplication of the human ſpecies would ever riſe to ſuch a degree as to exceed the quantity of proviſions produced by agriculture, and by the breeding of domeſtic animals, neceſſary for their exiſtence and happineſs. But, as long as men are actuated by ambition, by reſentment, and by many other hoſtile paſſions, war and animoſity, with all their train of bloodſhed and calamity, will forever continue to harraſs and perſecute the human kind. Let us, however, be humble. We cannot unfold the myſteries of Nature; but we may admire her operations, and ſubmit, with

with a becoming reſignation, to her irreſiſtible decrees. The man, if ſuch a man there be, whoſe ſtrength of mind enables him to obſerve ſtedfaſtly this conduct, is the only real philoſopher.

As formerly remarked, man is not the only animal that makes war with his own ſpecies. Quadrupeds, birds, fiſhes, inſects, independently of their appetite for food, occaſionally fight and kill each other. On this ſubject we ſhall confine ourſelves to a few examples derived from the inſect tribes.

A ſociety or hive of bees conſiſts of a female, of males, and of drones, or neuters. Theſe three kinds continue, for ſome time, in the moſt perfect harmony, and mutually protect and aſſiſt each other. The neuters, or working bees, diſcover the ſtrongeſt attachment and affection, to the males, even when in their worm ſtate. The neuters are armed with a deadly ſting, of which the males are deſtitute. Both are equally produced by the ſame mother, and live in the ſame family. But, notwithſtanding their temporary affection, there are times when the neuters cruelly maſſacre the males. Among the laws of poliſhed republics, we find ſome which are extremely barbarous. The Lacedemonians were allowed to kill ſuch of their children as were produced in a defective or maimed ſtate, becauſe they would become a burden upon the community. The laws of the Chineſe permit actions equally inhuman. We perhaps know not all the reaſons why the neuter bees treat the males with ſo much cruelty. There is a time, however, when the males become perfectly uſeleſs to the community; and it is not incurious to remark, that the general maſſacre never commences till this period arrives. Whenever a ſtranger-bee enters a hive, his temerity is uniformly puniſhed with death. But mortal combats are not unfrequent between bees belonging to the ſame hive. Theſe combats are moſt frequent in clear and warm weather. Sometimes two combatants come out of the hive cloſely faſtened to each other. At other times the attack is made in the air. But, in whatever way the battle begins, both combatants uniformly come to the ground before it is terminated by the death

death of one of the parties. When they reach the ground, each individual, like a wreſtler, endeavours to gain the moſt advantageous poſition for ſtinging his adverſary to death. Sometimes, though rarely, the ſting is left in the wound. If this were generally the caſe, every combat would prove fatal to two bees; for the victor could not long ſurvive the loſs of his ſting. Theſe battles ſometimes continue near an hour before one of the flies is left expiring on the ground.

Beſide theſe ſingle combats, general actions are not unfrequent, eſpecially in the ſwarming ſeaſon. When two ſwarms, or colonies, happen to contend for the ſame habitation, a general and bloody engagement immediately enſues. Theſe engagements often continue for hours, and never terminate without great havock on both ſides. The ſting is not the only weapon employed in war by bees. They are furniſhed with two ſtrong fangs or teeth, with which they cruelly tear each other. Even in general engagements, all the combats are ſingle. But, when the great ſlaughter of the males is committing, three or four neuters are not aſhamed to attack a ſingle fly.

Every waſp's neſt, about the beginning of October, exhibits a ſingular and a cruel ſcene. At this ſeaſon, the waſps ceaſe to bring nouriſhment to their young. From affectionate mothers or nurſes, they at once become barbarous ſtepmothers. They are worſe; for they drag the young worms from their cells, and carry them out of the neſt. Being thus expoſed to the weather, and deprived of nouriſhment, every one of them unavoidably periſhes. This devaſtation is not, like that of the honey-bees, confined to the male-worms. Here no worm, of whatever denomination or ſex, eſcapes the general and undiſtinguiſhed maſſacre. Beſide expoſing the worms to the weather, the waſps kill them with their fangs. This fact ſeems to be a violation of parental affection, one of the ſtrongeſt principles in animal nature. But the intentions of Nature, though they may often elude our reſearches, are never wrong. What appears to us cruel and unnatural in this inſtinctive devaſtation committed annually by the waſps, is perhaps an act of the greateſt

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mercy and compaſſion. Waſps are not, like the honey-bees, endowed with the inſtinct of laying up a ſtore of proviſions for winter ſubſiſtence. If not prematurely deſtroyed by their parents, the young muſt neceſſarily die a more cruel and lingering death, occaſioned by hunger. Hence this ſeemingly-harſh conduct in the œconomy of waſps, inſtead of affording an exception to the univerſal benevolence and wiſdom of Nature, is, in reality, a merciful inſtitution. Beſides, as the multiplication of waſps is prodigious, and as they are a noxious race both to man and other animals, and eſpecially to many tribes of inſects, if their increaſe were not checked by ſuch a dreadful carnage, their depredations, in a few years, would annihilate other ſpecies, break the chain of Nature, and even prove deſtructive to man and the larger animals.

The ſame inſtinctive ſlaughter, and probably for the ſame reaſons, is made by the hornets. Towards the end of October, all the worms and nymphs are dragged out of the neſt and killed. The neuters and males fall daily victims to the cold; ſo that, at the end of winter, a few fertile females only remain to continue the ſpecies.

According to the adopted plan, we ſhall finiſh this ſubject with ſome obſervations which may have a tendency to reconcile our minds to a ſyſtem ſo deſtructive to individuals of every ſpecies, that humanity, when not enlightened by a ray of philoſophy, is apt to revolt, and to brand Nature with cruelty and oppreſſion. Nature, it muſt be confeſſed, ſeems almoſt indifferent to individuals, who periſh every moment in millions, without any apparent compunction. But, with regard to ſpecies of every deſcription, her uniform and uninterrupted attention to the preſervation and continuation of the great ſyſtem of animation is conſpicuous, and merits admiration. Life, it ſhould appear, cannot be ſupported without the intervention of death. Through almoſt the whole of animated Nature, as we have ſeen, nothing but rapine, and the deſtruction of individuals, prevail. This deſtruction, however, has its uſe. Every animal, after death, adminiſters life and happineſs to a number of others. In many animals,

animals, the powers of digeſtion, and of aſſimilation, are confined to animal ſubſtances alone. If deprived of animal food, ſuch ſpecies, it is evident, could not exiſt. The chief force of this obſervation, it is admitted, is applicable ſolely to the carnivorous tribes, ſtrictly ſo denominated. But, from the facts formerly enumerated, and from the daily experience of every man, it is apparent, that, perhaps, no animal does or can exiſt totally independent of food that is or has been animated. Sheep, oxen, and all herbivorous animals, though not from choice, and even without conſciouſneſs, daily devour thouſands of inſects. This may be one reaſon why cattle of all kinds fatten ſo remarkably in rich paſtures; for inſects are always moſt numerous where the herbage is luxuriant. Nature is ſo profuſe in her animated productions, that no food can be eat, and no fluid can be drunk, in which animal ſubſtances, either in a living or dead ſtate, are not to be found.

To this reaſoning it may be objected, Why has Nature eſtabliſhed a ſyſtem ſo cruel? Why did ſhe render it neceſſary that one animal could not live without the deſtruction of another? To ſuch queſtions no anſwer can be either given or expected. No being, except the Supreme, can unfold this myſtery. Perhaps it even exceeds the limits of poſſibility to eſtabliſh ſuch an extended ſyſtem of animation upon any other foundation. From the general benevolence of the great Creator, we are warranted to conclude that this is really the caſe. But it is fruitleſs to dwell upon ſubjects which are inſcrutable, and far removed beyond the powers of human intellect. We ſhall therefore deſcend, and endeavour to point out ſome advantages which reſult from this myſterious inſtitution of Nature.

On this branch of the ſubject, the reader will eaſily perceive that much order or connection is not to be expected.

The hoſtilities of animals, mankind not excepted, give riſe to mutual improvement. Animals improve, and diſcover a ſuperiority of parts, in proportion to the number of enemies they have to attack or evade. The weak, and conſe-

confequently timid, are obliged to exert their utmoft powers in inventing and practifing every poffible mode of efcape. Pure inftinct powerfully prompts: but much is learned by experience and obfervation. Rapacious animals, on the contrary, by frequent difappointment, are obliged to provide againft the cunning and alertnefs of their prey. Herbivorous animals, as they have little difficulty in procuring food, are proportionally ftupid; but they would be ftill more ftupid, if they had no enemies to annoy them. Man, if his attention and talents were not excited by the animofities of his own fpecies, by the attacks of ferocious animals, and even by thofe of the infect tribes, would be an indolent, an incurious, a dirty, and an ignorant animal. Thofe of the human race, accordingly, who procure their food with little or no induftry, as we learn from a multitude of travellers and voyagers, are perfectly indolent and brutifhly ftupid. Timid animals never ufe the arts of defence, or provide againft danger, except from three caufes, pure inftinct, which is implanted in their natures, imitation, and experience. By experience, timid animals are taught the arts of evafion. Flight is inftinctive; but the modifications of it are acquired by imitation and experience.

Hoftilities, in fome inftances, feem to arife, not from a natural antipathy of one fpecies to another, but from a fcarcity of food. The celebrated Captain Cooke informs us, that, in Staten-Ifland, birds of prey affemble promifcuoufly with penguins and other birds, without the one offering any injury, or the other difcovering the fmalleft fymptom of terror. In that ifland, the rapacious birds, perhaps, find plenty of food from dead feals, fea-lions, and fifhes.

A profufion of animal life feems to be the general intention of Nature. For this purpofe, when not modified or reftrained by the induftry and intelligence of man, fhe uniformly covers the furface of the earth with trees and vegetables of every kind, which fupply myriads of animated beings with food. But the greateft poffible extenfion of life would ftill be wanting, if animals did not prey upon each other. If all animals were to live upon vegetables

alone,

alone, many ſpecies, and millions of individuals, which now enjoy life and happineſs, could have no exiſtence; for the productions of the earth would not be ſufficient to ſupport them. But, by making animals feed upon each other, the ſyſtem of animation and of happineſs is extended to the greateſt poſſible degree. In this view, Nature, inſtead of being cruel and oppreſſive, is highly generous and beneficent.

To diminiſh the number of noxious animals, and to augment that of uſeful vegetables, has been the uniform ſcope of human induſtry. A few ſpecies of animals only are of immediate utility to man. Theſe he either cultivates with care, or hunts for his prey. The ox, the ſheep, the goat, and other animals which are under his peculiar protection, he daily uſes for food. This is not cruelty. He has a right to eat them: For, like Nature, though he occaſionally deſtroys domeſtic animals, a timid and docile race of beings, by his culture and protection he gives life and happineſs to millions, which, without his aid, could have no exiſtence. The number of individuals, among animals of this deſcription, if they were not cheriſhed and defended by man, would be extremely limited; for, by the mildneſs of their diſpoſitions, the comparative weakneſs of their arms, and the univerſal and ſtrong appetite for them by rapacious quadrupeds and birds of prey, though the ſpecies might, perhaps, be continued, the number of individuals would, of neceſſity, be very ſmall.

There is a wonderful balance in the ſyſtem of animal deſtruction. If the general profuſion of the animated productions of Nature had no other check than the various periods to which their lives, when not extinguiſhed by hoſtilities of one kind or another, are limited, the whole would ſoon be annihilated by an univerſal famine, and the earth, inſtead of every where teeming with animals, would, unleſs repeopled by a new creation, exhibit nothing but a mute, a lifeleſs, and an inactive ſcene. If even a ſingle ſpecies were permitted to multiply without diſturbance, the food of other ſpecies would be exhauſted, and, of courſe, a period would be put to their

 exiſtence.

existence. The herbivorous and frugivorous races, if not restrained by the carnivorous, would soon increase to a hurtful degree. Carnivorous animals are the barriers fixed by Nature to noxious inundations of other kinds. The carnivorous tribes may be compared to the hoe and the pruning hook, which, by diminishing the number of plants when too close, or lopping off their luxuriancies, make the others grow to greater perfection. To those swarms of insects which cover the surface of the earth, are opposed an army of birds, an active, a vigilant, and a voracious race. Hares, rabbits, mice, rats, are exposed to the depredations of carnivorous quadrupeds and birds. The larger cattle, as the ox, the deer, the sheep, &c. are not exempted from enemies: And man, by the superiority of his mental powers, checks the multiplication of the carnivorous tribes, and maintains the balance and empire of the animal system. Those species which are endowed with uncommon fertility have the greatest number of enemies. The caterpillar, the puceron, and insects in general, one of the most prolific tribes of animals, are attacked and devoured by numerous hostile bands. No species, however, is ever exhausted. The balance between gain and loss is perpetually preserved. The earth, the seas, the atmosphere, may be considered as an immense and variegated pasture. In this view, it is most judiciously cultivated and stocked by the numerous animated beings which it is destined to support. Every animal and every vegetable furnish subsistence to particular species. Thus, nothing of value is lost; and every species is abundantly supplied with food.

That the general balance of animation is constantly preserved, we learn from daily experience. The reader, however, I presume, will not be displeased to have some examples of the modes employed by Nature to accomplish this effect suggested to him.

After an inundation of the Nile, the lower parts of Egypt are greatly infested with serpents, frogs, mice, and other vermin. At that period, the storks resort thither in immense multitudes, and devour the serpents, frogs, and mice, which, without this dreadful carnage,

nage, would be highly noxious to the inhabitants. Belon, a moſt ingenious and faithful French Naturaliſt, remarks, that, in many places, the land could not be inhabited, if the ſtorks did not deſtroy the amazing numbers of mice which frequently appear in Paleſtine, and other parts of the Eaſt bordering upon Egypt. The Egyptian vulture, ſays Haſſelquiſt, is of ſingular benefit to that country. It eats up all the dung and offals in the towns, and the carcaſes of camels, horſes, aſſes, &c. in the fields, which, if not quickly devoured, would, in that warm climate, by their putreſcency, be productive of diſeaſe and death to the inhabitants. Putrid carcaſes, in all countries, are both offenſive to the noſtrils and hurtful to health. But Nature, by various inſtruments, ſoon removes the evil. An animal no ſooner dies, than, in a very ſhort time, he is conſumed by bears, wolves, foxes, dogs, and ravens. In ſituations where theſe animals dare not approach, as in the vicinity of towns and villages, a dead horſe, in a few days, is devoured by myriads of maggots. In the uncultivated parts of America, ſerpents and ſnakes of different kinds abound. After it was diſcovered that ſwine greedily devoured ſerpents, hogs were uniformly kept by all new ſettlers. Caterpillars are deſtructive to the leaves and fruits of plants. Their numbers and varieties are immenſe. But their devaſtations are checked by many enemies. Without a profuſion of caterpillars, moſt of the ſmaller birds, eſpecially when young, could not be ſupported. By devouring the caterpillars, theſe birds preſerve the fruits of the earth from total deſtruction. Mr. Bradley, in his General Treatiſe of Huſbandry and Gardening, has publiſhed a letter, in which the author oppoſes the common opinion, that birds, and particularly ſparrows, do much miſchief in our gardens and fields. The fact is admitted. But the great utility of theſe birds is overlooked: For this author proves, that they are much more uſeful than noxious. He ſhows, that a pair of ſparrows, during the time they have their young to feed, deſtroy, every week, 3360 caterpillars. This calculation he founded upon actual obſervation. He diſcovered that the two parents carried to the neſt 40 caterpillars

terpillars in an hour. He then ſuppoſes, which is a moderate ſuppoſition, that the ſparrows enter the neſt only 12 hours each day, which is a daily conſumption of 480 caterpillars. This ſum, multiplied by 7, or the days in a week, gives 3360 caterpillars extirpated weekly from a garden. The utility of theſe birds is not limited to this circumſtance alone; for they likewiſe feed their young with butterflies, and other winged inſects, each of which, if not deſtroyed in this manner, would be the parent of ſeveral hundreds of caterpillars. Thoſe butterflies and caterpillars which are covered with hair are rejected by ſome birds, who prefer flies of a ſmoother and ſmaller kind. But theſe hairy ſpecies, it ſhould be conſidered, are the food of the worms which are transformed into thoſe ſmaller flies that afford nouriſhment to the birds which reject the hairy caterpillars and butterflies.

Shell-fiſhes are extremely prolific, and ſo ſtrongly fortified by Nature, that their increaſe, one ſhould imagine, would ſoon augment to a degree that might be hurtful to other ſpecies. Their noxious multiplication, however, is checked by numberleſs enemies. But their moſt deſtructive enemy is the trochus, which is a kind of ſea-ſnail. This animal is furniſhed with a ſtrong, muſcular, hollow trunk, bordered at the extremity with a cartilage toothed like a ſaw. Againſt this inſtrument, which acts like an augre, no ſhell, however hard or thick, is a ſufficient defence. Theſe animals, called *trochi*, fix themſelves upon an oyſter or a muſcle, bore through the ſhell with their trunk, and devour their prey at their leiſure. The animal attacked, if a bivalve, may open or ſhut its ſhell; but no efforts of this kind can be of any avail; for the trochus remains immoveably fixed till it has completely ſucked out the vitals of its prey. In this cruel occupation the trochus often continues for days, and even weeks, before the life of the animal attacked is fully extinguiſhed. The operation of the trochus may be ſeen in the ſhells of many oyſters, muſcles, and other ſhell-fiſhes; for their ſhells are often pierced with a number of circular holes.

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The amazing ſtrength of the whale, one ſhould imagine, would ſecure it from the inſults of every other animal. But, beſide the annual depredations made by man upon the cetaceous tribes, they are often attacked and killed by the ſword-fiſh. The ſnout of this comparatively-ſmall animal is armed with a long, hard, projection of bone, each edge of which is furniſhed with a number of ſtrong, flat, and ſharp points, or teeth, ſome of which, eſpecially near the ſnout, are an inch and a half in length. With this inſtrument the ſword-fiſh boldly attacks the whale. I have often had the pleaſure, ſays Pere Labat *, of ſeeing their combats. The whale has no other defence but its tail, with which it endeavours to ſtrike its antagoniſt. But, as the ſword-fiſh is more active and nimble than the whale, he eaſily parries the blow by ſpringing into the air, and renewing the attack with his ſaw-like inſtrument. Whenever he ſucceeds, the ſea is dyed red with the blood iſſuing from the wound. The fury of the whale appears from the vehemence with which it laſhes the waters, each ſtroke reſounding like the report of a cannon.

Many ſmall birds, and particularly the wren and the tit-mouſe, may be ſeen, during the winter-ſeaſon, pecking at the buds and branches of trees in our gardens. To theſe little animals Nature has entruſted the charge of preventing the noxious multiplication of thoſe worms which feed upon fruits. Nature, as far as we are able to trace her operations, does nothing in vain, or without ſome valuable intention. No animals exiſt which are not uſeful, either by affording nouriſhment to, or preventing the hurtful increaſe of, other ſpecies.

Upon the whole. every animated being that inhabits this globe ſeems to be deſtined by Nature, not for its own individual exiſtence and happineſs alone, but likewiſe for the exiſtence and happineſs of other animated beings. A circle of animation and of deſtruction goes perpetually round. This is the œconomy of Nature. Different ſpecies of animals live by the mutual deſtruction of each other.

* Nouv. Voyage, tom. 6. pag. 150. S.

other. Even among individual men, the ſtrong too often oppreſs the weak; but, on the other hand, the wiſe inſtruct the ignorant. Theſe are the bonds of ſociety, and the ſources of improvement.

CHAPTER XV.

Of the Artifices of Animals.

IT will be recollected, that many inſtances of the dexterity and artifices employed by different animals in various parts of their manners and œconomy, have been occaſionally mentioned in ſeveral of the foregoing chapters. This circumſtance, to avoid repetitions, will neceſſarily render the preſent chapter proportionally ſhort.

The artifices practiſed by animals proceed from ſeveral motives, many of which are purely inſtinctive, and others are acquired by experience and imitation. Their arts, in general, are called forth and exerted by three great and important cauſes, the love of life, the deſire of multiplying and continuing the ſpecies, and that ſtrong attachment which every animal has to its offspring. Theſe are the ſources from which all the movements, all the dexterity, and all the ſagacity of animals originate. The principle of ſelf-preſervation is inſtinctive, and ſtrongly impreſſed upon the minds of all animated beings. It gives riſe to innumerable arts of attack and defence, and not unfrequently to ſurpriſing exertions of ſagacity and genius. The ſame remark is applicable to the deſire of multiplication, and to parental affection. Upon this ſubject we ſhall, as uſual, give ſome examples of animal artifice, which may both amuſe and inform ſome readers.

When a bear, or other rapacious animal, attacks cattle, they inſtantly join and form a phalanx for mutual defence. In the ſame circumſtances, horſes rank up in lines, and beat

beat off the enemy with their heels. Pontoppidan tells us, that the ſmall Norwegian horſes, when attacked by bears, inſtead of ſtriking with their hind-legs, rear, and, by quick and repeated ſtrokes with their fore-feet, either kill the enemy, or oblige him to retire. This curious, and generally ſucceſsful defence, is frequently performed in the woods, while a traveller is ſitting on the horſe's back. It has often been remarked, that troops of wild horſes, when ſleeping either in plains or in the foreſt, have always one of their number awake, who acts as a centinel, and gives notice of any approaching danger.

Margraaf informs us, that the monkeys in Brazil, while they are ſleeping on the trees, have uniformly a centinel to warn them of the approach of the tiger or other rapacious animals; and that, if ever this centinel is found ſleeping, his companions inſtantly tear him in pieces for his neglect of duty. For the ſame purpoſe, when a troop of monkeys are committing depredations on the fruits of a garden, a centinel is placed on an eminence, who, when any perſon appears, makes a certain chattering noiſe, which the reſt underſtand to be a ſignal for retreat, and immediately fly off and make their eſcape.

The deer-kind are remarkable for the arts they employ in order to deceive the dogs. With this view the ſtag often returns twice or thrice upon his former ſteps. He endeavours to raiſe hinds or younger ſtags to follow him, and to draw off the dogs from the immediate object of their purſuit. If he ſucceeds in this attempt, he then flies off with redoubled ſpeed, or ſprings off at a ſide, and lies down on his belly to conceal himſelf. When in this ſituation, if by any means his foot is recovered by the dogs, they purſue him with more advantage, becauſe he is now conſiderably fatigued. Their ardour increaſes in proportion to his feebleneſs; and the ſcent becomes ſtronger as he grows warm. From theſe circumſtances the dogs augment their cries and their ſpeed; and, though the ſtag employs more arts of eſcape than formerly, as his ſwiftneſs is diminiſhed, his doublings and artifices become gradually leſs effectual. No other reſource is now left him but to fly from the earth which he treads, and go in-

to

to the waters, in order to cut off the ſcent from the dogs, when the huntſmen again endeavour to put them on the track of his foot. After taking to the water, the ſtag is ſo much exhauſted that he is incapable of running much farther, and is ſoon *at bay*, or, in other words, turns and defends himſelf againſt the hounds. In this ſituation he often wounds the dogs, and even the huntſmen, by blows with his horns, till one of them cuts his hams to make him fall, and then puts a period to his life. The fallow-deer is more delicate, leſs ſavage, and approaches nearer to the domeſtic ſtate than the ſtag. The males, during the rutting ſeaſon, make a bellowing noiſe, but with a low and interrupted voice. They are not ſo furious as the ſtag. They never depart from their own country in queſt of females; but they bravely fight for the poſſeſſion of their miſtreſſes. They aſſociate in herds, which generally keep together. When great numbers are aſſembled in one park, they commonly form themſelves into two diſtinct troops, which ſoon become hoſtile, becauſe they are both ambitious of poſſeſſing the ſame part of the incloſure. Each of theſe troops has its own chief or leader, who always marches foremoſt, and he is uniformly the oldeſt and ſtrongeſt of the flock. The others follow him; and the whole draw up in order of battle, to force the other troop, who obſerve the ſame conduct, from the beſt paſture. The regularity with which theſe combats are conducted is ſingular. They make regular attacks, fight with courage, and never think themſelves vanquiſhed by one check; for the battle is daily renewed till the weaker are completely defeated, and obliged to remain in the worſt paſture. They love elevated and hilly countries. When hunted, they run not ſtraight out, like the ſtag, but double, and endeavour to conceal themſelves from the dogs by various artifices, and by ſubſtituting other animals in their place. When fatigued and heated, however, they take the water; but never attempt to croſs ſuch large rivers as the ſtag. Thus, between the chace of the fallow-deer and of the ſtag, there is no material difference. Their ſagacity and inſtincts, their ſhifts and doublings, are the ſame, only they are more frequently practiſed

practiſed by the fallow-deer. As he runs not ſo far before the dogs, and is leſs enterpriſing, he has oftener occaſion to change, to ſubſtitute another in his place, to double, return upon his former tracks, &c. which renders the hunting of the fallow-deer more ſubject to inconveniencies than that of the ſtag.

The roe-deer is inferior to the ſtag and fallow-deer both in ſtrength and ſtature; but he is endowed with more gracefulneſs, courage, and vivacity. His eyes are more brilliant and animated. His limbs are more nimble; his movements are quicker, and he bounds with equal vigour and agility. He is likewiſe more crafty, conceals himſelf with greater addreſs, and derives ſuperior reſources from his inſtincts. Though he leaves behind him a ſtronger ſcent than the ſtag, which increaſes the ardour of the dogs, he knows how to evade their purſuit, by the rapidity with which he commences his flight, and by his numerous doublings. He delays not his arts of defence till his ſtrength begins to fail him; for he no ſooner perceives that the firſt efforts of a rapid flight have been unſucceſsful, than he repeatedly returns upon his former ſteps; and, after confounding, by theſe oppoſite motions, the direction he has taken, after intermixing the preſent with the paſt emanations of his body, he, by a great bound, riſes from the earth, and, retiring to a ſide, lies down flat on his belly. In this immoveable ſituation, he often allows the whole pack of his deceived enemies to paſs very near him. The roe-deer differs from the ſtag in diſpoſition, manners, and in almoſt every natural habit. Inſtead of aſſociating in herds, they live in ſeparate families. The two parents and the young go together, and never mingle with ſtrangers. They are conſtant in their amours, and never unfaithful like the ſtag. The females commonly produce two fawns, the one a male and the other a female. Theſe young animals, who are brought up and nouriſhed together, acquire a mutual affection ſo ſtrong, that they never depart from each other. This attachment is ſomething more than love; for, though always in company, they feel the rut but once a year, and it continues only fifteen days. At this period the father

drives off the fawns, as if he intended that they ſhould yield their place to thoſe which are to ſucceed, in order to form new families for themſelves. After the rutting ſeaſon, however, is paſt, the fawns return to their mother, and continue with her ſome time longer; after which they ſeparate forever, and remove to a diſtance from the place of their nativity. When about to bring forth, the female ſeparates from the male; and, to avoid the wolf, her moſt dangerous enemy, conceals herſelf in the deepeſt receſſes of the foreſt. In a week or two the fawns are able to follow her. When threatened with danger, ſhe hides them in a cloſe thicket; and, ſo ſtrong is her parental affection, that, in order to preſerve her offſpring from deſtruction, ſhe preſents herſelf to be chaced.

Hares poſſeſs not, like rabbits, the art of digging retreats in the earth. But they neither want inſtinct ſufficient for their own preſervation, nor ſagacity for eſcaping their enemies. They form ſeats or neſts on the ſurface of the ground, where they watch, with the moſt vigilant attention, the approach of any danger. In order to deceive, they conceal themſelves between clods of the ſame colour with that of their own hair. When purſued, they firſt run with rapidity, and then double, or return upon their former ſteps. From the place of ſtarting, the females run not ſo far as the males; but they double more frequently. Hares hunted in the place where they were brought forth, ſeldom remove to a great diſtance from it, but return to their form; and, when chaced two days ſucceſſively, on the ſecond day they perform the ſame doublings they had practiſed the day before. When hares run ſtraight out to a great diſtance, it is a proof that they are ſtrangers. Male hares, eſpecially during the moſt remarkable period of rutting, which is in the months ...nuary, February, and March, ſometimes perform ...es of ſeveral miles in queſt of mates; but, as ſoon ...re ſtarted by dogs, they fly back to the place of ...tivity. 'I have ſeen a hare,' Fouilloux remarks, ...racious, that, after hearing the hunter's horn, he ...rted from his form, and, though at the diſtance of a quarter of a league, went to ſwim in a pool, and lay

'down

'down on the ruſhes in the middle of it, without being 'chaced by the dogs. I have ſeen a hare, after running 'two hours before the dogs, puſh another from his ſeat, 'and take poſſeſſion of it. I have ſeen others ſwim over 'two or three ponds, the narroweſt of which was eighty 'paces broad. I have ſeen others, after a two hours chace, 'run into a ſheep-fold and lie down among them. I have 'ſeen others, when hard puſhed, run in among a flock of 'ſheep, and would not leave them. I have ſeen others, 'after hearing the noiſe of the hounds, conceal themſelves 'in the earth. I have ſeen others run up one ſide of a 'hedge and return by the other, when there was nothing 'elſe between them and the dogs. I have ſeen others, 'after running half an hour, mount an old wall, ſix feet 'high, and clap down in a hole covered with ivy. Laſtly, 'I have ſeen others ſwim over a river, of about eighty pa-'ces broad, oftener than twice, in the length of two 'hundred paces.'

The fox has, in all ages and nations, been celebrated for craftineſs and addreſs. Acute and circumſpect, ſagacious and prudent, he diverſifies his conduct, and always reſerves ſome art for unforeſeen accidents. Though nimbler than the wolf, he truſts not entirely to the ſwiftneſs of his courſe. He knows how to enſure ſafety, by providing himſelf with an aſylum, to which he retires when danger appears. He is not a vagabond, but lives in a ſettled habitation and in a domeſtic ſtate. The choice of ſituation, the art of making and rendering a houſe commodious, and of concealing the avenues which lead to it, imply a ſuperior degree of ſentiment and reflection. The fox poſſeſſes theſe qualities, and employs them with dexterity and advantage. He takes up his abode on the border of a wood, and in the neighbourhood of cottages. Here he liſtens to the crowing of the cocks and the noiſe of the poultry. He ſcents them at a diſtance. He chooſes his time with great judgment and diſcretion. He conceals both his route and his deſign. He moves forward with caution, ſometimes even trailing his body, and ſeldom makes a fruitleſs expedition. When he leaps the wall, or gets in underneath it, he ravages the court-yard, puts all the

the fowls to death, and then retires quietly with his prey, which he either conceals under the herbage, or carries off to his kennel. In a ſhort time he returns for another, which he carries off and hides in the ſame manner, but in a different place. In this manner he proceeds, till the light of the ſun, or ſome movements perceived in the houſe, admoniſh him that it is time to retire to his den. He does much miſchief to the bird-catchers. Early in the morning he viſits their nets and their bird-lime, and carries off ſucceſſively all the birds that happen to be entangled. The young hares he hunts in the plains, ſeizes old ones in their ſeats, digs out the rabbits in the warrens, finds out the neſts of partridges, quails, &c. ſeizes the mothers on the eggs, and deſtroys a prodigious number of game. Dogs of all kinds ſpontaneouſly hunt the fox. Though his odour be ſtrong, they often prefer him to the ſtag or the hare. When purſued he runs to his hole; and it is not uncommon to ſend in terriers to detain him till the hunters remove the earth above, and either kill or ſeize him alive. The moſt certain method, however, of deſtroying a fox is to begin with ſhutting up the hole, to ſtation a man with a gun near the entrance, and then to ſearch about with the dogs. When they fall in with him he immediately makes for his hole. But, when he comes up to it, he is met with a diſcharge from the gun. If the ſhot miſſes him, he flies off full ſpeed, takes a wide circuit, and returns again to the hole, where he is fired upon a ſecond time; but, when he diſcovers that the entrance is ſhut, he darts away ſtraight forward, with the intention of never reviſiting his former habitation. He is next purſued by the hounds, whom he ſeldom fails to fatigue; becauſe, with much cunning, he paſſes through the thickeſt part of the foreſt, or places of the moſt difficult acceſs, where the dogs are hardly able to follow him; and, when he takes to the plains, he runs ſtraight out, without either ſtopping or doubling. But the moſt effectual way of deſtroying foxes is to lay ſnares baited with live pigeons, fowls, &c. The fox is an exceedingly voracious animal. Beſide all kinds of fleſh and fiſhes, he devours, with equal avidity, eggs, milk, cheeſe, fruits, and particu-

particularly grapes. He is ſo extremely fond of honey, that he attacks the neſts of wild bees. They at firſt put him to flight by numberleſs ſtings; but he retires for the ſole purpoſe of rolling himſelf on the ground, and of cruſhing the bees. He returns to the charge ſo often, that he obliges them to abandon the hive, which he ſoon uncovers, and devours both the honey and the wax. Some time before the female brings forth, ſhe retires, and ſeldom leaves her hole, where ſhe prepares a bed for her young. When ſhe perceives that her retreat is diſcovered, and that her young have been diſturbed, ſhe carries them off, one by one, into a new habitation. The fox ſleeps in a round form, like the dog; but, when he only repoſes himſelf, he lies on his belly with his hind-legs extended. It is in this ſituation that he eyes the birds on the hedges and trees. The birds have ſuch an antipathy againſt him, that they no ſooner perceive him than they ſend forth ſhrill cries to advertiſe their neighbours of the enemy's approach. The jays and blackbirds, in particular, follow the fox from tree to tree, ſometimes two or three hundred paces, often repeating the watch-cries. The Count de Buffon kept two young foxes, which, when at liberty, attacked the poultry; but, after they were chained, they never attempted to touch a ſingle fowl. A living hen was fixed near them for whole nights; and, though deſtitute of victuals for many hours, in ſpite of hunger and of opportunity, they never forgot that they were chained, and gave the hen no diſturbance.

In Kamtſchatka, the animals called *gluttons* employ a ſingular ſtratagem for killing the fallow-deer. They climb up a tree, and carry with them a quantity of that ſpecies of moſs of which the deer are very fond. When a deer approaches near the tree, the glutton throws down the moſs. If the deer ſtops to eat the moſs, the glutton inſtantly darts down upon its back, and, after fixing himſelf firmly between the horns, tears out its eyes, which torments the animal to ſuch a degree, that, whether to put an end to its torments, or to get rid of its cruel enemy, it ſtrikes its head againſt the trees till it falls down dead. The glutton divides the fleſh of the deer into convenient portions,

portions, and conceals them in the earth to ſerve for future proviſions. The gluttons on the river Lena kill horſes in the ſame manner *.

There are ſeveral ſpecies of rats in Kamtſchatka. The moſt remarkable kind is called *tegulchitch* by the natives. Theſe rats make neat and ſpacious neſts under ground. They are lined with turf, and divided into different apartments, in which the rats depoſit ſtores of proviſions for ſupporting them during the winter. It is worthy of remark, that the rats of this country never touch the proviſions laid up for the winter, except when they cannot procure nouriſhment any where elſe. Theſe rats, like the Tartars, change their habitations. Sometimes they totally abandon Kamtſchatka for ſeveral years, and their retreat greatly alarms the inhabitants, which they conſider as a preſage of a rainy ſeaſon, and of a bad year for hunting. The return of theſe animals is, of courſe, looked upon as a good omen. Whenever they appear, the happy news is ſoon ſpread over all parts of the country. They always take their departure in the ſpring, when they aſſemble in prodigious numbers, and traverſe rivers, lakes, and even arms of the ſea. After they have made a long voyage, they frequently lie motionleſs on the ſhore, as if they were dead. When they recover their ſtrength they recommence their march. The inhabitants of Kamtſchatka are very ſolicitous for the preſervation of theſe animals. They never do the rats any injury, but give them every aſſiſtance when they lie weakened and extended on the ground. They generally return to Kamtſchatka about the month of October; and they are ſometimes met with in ſuch prodigious numbers that travellers are obliged to ſtop two hours till the whole troop paſſes. The track of ground they travel in a ſingle ſummer is not leſs wonderful than the regularity they obſerve in their march, and that inſtinctive impulſe which enables them to foreſee, with certainty, the changes of times and of ſeaſons.

With regard to *Birds*, their artifices are not leſs numerous nor leſs ſurpriſing than thoſe of quadrupeds. The eagle and hawk-kinds are remarkable for the ſharpneſs of their ſight,

* Gazette Literaire, vol. 1. pag. 481. S.

ſight, and the arts they employ in catching their prey. Their movements are rapid or ſlow, according to their intentions, and the ſituation of the animals they wiſh to devour. Rapacious birds uniformly endeavour to riſe higher in the air than their prey, that they may have an opportunity of darting forcibly down upon it with their pounces. To counteract theſe artifices, Nature has endowed the ſmaller and more innocent ſpecies of birds with many arts of defence. When a hawk appears, the ſmall birds, if they find it convenient, conceal themſelves in hedges or bruſh-wood. When deprived of this opportunity, they often, in great numbers, ſeem to follow the hawk, and to expoſe themſelves unneceſſarily to danger, while, in fact, by their numbers, their perpetual changes of direction, and their uniform endeavours to riſe above him, they perplex the hawk to ſuch a degree, that he is unable to fix upon a ſingle object; and, after exerting all his art and addreſs, he is frequently obliged to relinquiſh the purſuit. When in the extremity of danger, and after employing every other artifice in vain, ſmall birds have been often known to fly to men for protection. This is a plain indication that theſe animals, though they in general avoid the human race, are by no means ſo much afraid of man as of rapacious birds.

The ravens often frequent the ſea-ſhores in queſt of food. When they find their inability to break the ſhells of muſcles, &c. to accompliſh this purpoſe they uſe a very ingenious ſtratagem: They carry a muſcle, or other ſhell-fiſh, high up in the air, and then daſh it down upon a rock, by which means the ſhell is broken, and they obtain the end they had in view.

The wood-pecker is furniſhed with a very long and voluble tongue. It feeds upon ants and other ſmall inſects. Nature has endowed this bird with a ſingular inſtinct. It knows how to procure food without ſeeing its prey. It attaches itſelf to the trunks or branches of decayed trees; and, wherever it perceives a hole or crevice, it darts in its long tongue, and brings it out loaded with inſects of different kinds. This operation is certainly inſtinctive; but the inſtinct is aſſiſted by the inſtruction of the parents;

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for the young are no ſooner able to fly, than the parents, by the force of example, teach them to reſort to trees, and to inſert their tongues indiſcriminately into every hole or fiſſure.

Of the œconomy of *Fiſhes*, as formerly remarked, our knowledge is extremely limited. But, as the ocean exhibits a perpetual and a general ſcene of attack and defence, the arts of aſſault and of evaſion muſt, of courſe, be exceedingly various. For the preſervation of ſome ſpecies of fiſhes, Nature has armed them with ſtrong and ſharp pikes. Others, as the perch-kind, are defended with ſtrong bony rays in their fins. Others, as the univalve ſhell-fiſh, retire into their ſhells upon the approach of danger. The bivalves and multivalves, when attacked, inſtantly ſhut their ſhells, which, in general, is a ſufficient protection to them. Some univalves, as the limpet-kind, attach themſelves ſo firmly, by excluding the air, to rocks and ſtones, that, unleſs quickly ſurpriſed, no force inferior to that of breaking the ſhell can remove them. The flying-fiſh, when purſued, darts out of the water, and takes refuge in the air, in which it is for ſome time ſupported by the operation of its large and pliable fins. The torpedo is furniſhed with a remarkable apparatus for ſelf-preſervation: It repels every hoſtile attempt by an electrical ſtroke, which confounds and intimidates its enemies. Several fiſhes, and particularly the ſalmon-kind, when about to generate, leave the ocean, aſcend the rivers, depoſit their eggs in the ſand, and, after making a proper *nidus* for their future progeny, return to the ocean from whence they came. Others, as the herring-kind, though they ſeldom go up rivers, aſſemble in myriads from all quarters, and approach the ſhores, or aſcend arms of the ſea, for the purpoſe of propagating the ſpecies, and cheriſhing their offspring. When that operation is performed, they leave the coaſts, and diſperſe in the ocean, till the ſame inſtinctive impulſe forces them to obſerve a ſimilar conduct next ſeaſon. This migration of ſalmons, herrings, and many other fiſhes, from the ocean to the rivers or ſhores, is of infinite advantage to mankind. They ſupply us occaſionally, and in ſome countries, as

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Great-Britain, and particularly Scotland, with abundance of nouriſhing and luxurious food; and, if our fiſheries were once put upon a proper footing, they would ſoon conſtitute one of the moſt powerful incentives to induſtry, and become a great and important ſource of national ſtrength and proſperity.

The *inſect* tribes, though comparatively diminutive, are not deficient in artifice and addreſs. With much art the ſpider ſpins his web. It ſerves him the double purpoſe of an habitation, and of a machine for catching his food. With incredible patience and perſeverance he lies in the center of his web for days, and ſometimes for weeks, before an ill-fated fly happens to be entangled. One ſpecies of ſpider, which is ſmall, of a blackiſh colour, and frequents cottages or out-houſes, I have known to live during the whole winter months without almoſt the poſſibility of receiving any nouriſhment; for, during that period, not a fly of any kind could be diſcovered in the apartment. If they had been in a torpid ſtate, like ſome other animals, the wonder of their ſurviving the want of food ſo long would not have been ſo great. But, in the ſevereſt weather, and through the whole courſe of the winter, they were perfectly active and lively. Neither did they ſeem to be in the leaſt emaciated.

The *formica-leo*, or ant-lion, is a ſmall inſect, ſomewhat reſembling a wood-louſe, but larger. Its head is flat, and armed with two fine moveable crotchets, or pincers. It has ſix legs, and its body, which terminates in a point, is compoſed of a number of membranous rings. In the ſand, or in finely pulveriſed earth, this animal digs a hole in the form of a funnel, at the bottom of which it lies in ambuſh for its prey. As it always walks backward, it cannot purſue any inſect. To ſupply this defect, it lays a ſnare for them, and eſpecially for the ant, which is its favourite food. It generally lies concealed under the ſand in the bottom of its funnel or trap, and ſeldom exhibits more than the top of its head. In digging a funnel, the formica-leo begins with tracing a circular furrow in the ſand, the circumference of which determines the ſize of

the funnel, which is often an inch deep. After the firſt furrow is made, the animal traces a ſecond, which is always concentric with the firſt. It throws out the ſand, as with a ſhovel, from the ſucceſſive furrows or circles, by means of its ſquare flat head and one of its fore-legs. It proceeds in this manner till it has completed its funnel, which it does with ſurpriſing promptitude and addreſs. At the bottom of this artful ſnare it lies concealed and immoveable. When an ant happens to make too near an approach to the margin of the funnel, the ſides of which are very ſteep, the fine ſand gives way, and the unwary animal tumbles down to the bottom. The formica-leo inſtantly kills the ant, buries it under the ſand, and ſucks out its vitals. It afterwards puſhes out the empty ſkin, repairs the diſorder introduced into its ſnare, and again lies in ambuſh for a freſh prey.

We formerly took ſome notice of that ſpecies of ſpider which carries her eggs in a bag attached to her belly. A ſpider of this kind was thrown into the funnel of a formica-leo. The latter inſtantly ſeized the bag of eggs, and endeavoured to drag it under the ſand. The ſpider, from a ſtrong love of offspring, allowed its own body to be carried along with the bag. But the ſlender ſilk by which it was fixed to the animal's belly broke, and a ſeparation took place. The ſpider immediately ſeized the bag with her pincers, and exerted all her efforts to regain the object of her affections. But theſe efforts were ineffectual; for the formica-leo gradually ſunk the bag deeper and deeper in the ſand. The ſpider, however, rather than quit her hold, allowed herſelf to be buried alive. In a ſhort time, the obſerver removed the ſand, and took out the ſpider. She was perfectly unhurt; for the formica-leo had not made any attack upon her. But, ſo ſtrong was her attachment to her eggs, that, though frequently touched with a twig, ſhe would not relinquiſh the place which contained them *.

When arrived at its full growth, the formica-leo gives up the buſineſs of an enſnaring hunter. He deſerts his former

* Oeuvres de Bonnet, vol. 4. pag. 295. 8vo edit. Amſterdam 1769. S.

former habitation, and crawls about for ſome time on the ſurface of the earth. He at laſt retires under the ground; ſpins a round ſilken pod, and is ſoon transformed into a fly.

CHAPTER XVI.

Of the Society of Animals.

THE aſſociating principle, from which ſo many advantages are derived, is not confined to the human ſpecies, but extends, in ſome inſtances, to every claſs of animals.

It is remarked by Buffon, and ſome other authors, that the ſtate of Nature, which had long occupied the attention and reſearches of philoſophers, was rejected by them after the diſcovery was made. In the eſtimation of the authors alluded to, the ſavage ſtate is the ſtate of Nature. The firſt natural condition of mankind is the union of a male and female. Theſe produce a family, who, from neceſſity, or, in other words, from parental and filial affection, continue together, and aſſiſt each other in procuring food and ſhelter. This family, like moſt families in eſtabliſhed civil ſocieties, feel their own weakneſs, and their inability to ſupply their wants without more powerful reſources than their feeble exertions. When this wandering and defenceleſs family accidentally meet with another family in the ſame condition, Nature, it is ſaid, teaches them to unite for mutual ſupport and protection. The aſſociation of two families may be conſidered as the firſt formation of a tribe or nation. When a number of tribes happen to unite, they only become a larger or more numerous nation. A ſingle pair, it is true, if placed in a ſituation where plenty of food could be procured without much labour, might, in a ſucceſſion

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of ages, produce any indefinite number. This is precifely the fituation in which Mofes has placed our firft parents. He has added another circumftance highly favourable to a fpeedy population. Inftead of the prefent brevity of human life, he informs us, that men, in the firft periods of the world, lived and propagated feveral hundred years.

In countries thinly peopled with favages, it is extremely probable, that focieties are formed by the gradual union of families and tribes. The increafe of power arifing from mutual affiftance, and a thoufand other comfortable circumftances, foon contribute to cement more firmly the affociated members. Some of the arts of life, befide that of hunting, are occafionally difcovered either by accident or by the ingenuity of individuals. In this manner, gradual advances are made from the favage to the civilized condition of mankind. This is a very fhort view of the origin of fociety, which has been adopted by moft authors both ancient and modern, though many of them have derived the affociating principle from very different, and even from oppofite caufes, which it is no part of our plan either to enumerate or to refute. Some writers, as Ariftotle, and a few moderns, implicit followers of his opinions, deny that man is naturally a gregarious or affociating animal. To render this notion confiftent with the actual and univerfal ftate of the human race, thefe authors have had recourfe to puerile conceits, and to queftionable facts, which it would be fruitlefs to relate. Other writers, poffeffed of greater judgment and difcernment, and lefs warped with vanity and hypothetical phantoms, have derived the origin of fociety from its real and only fource, Nature herfelf.

That the affociating principle is inftinctive, hardly requires a proof. An appeal to the feelings of any human being, and to the univerfal condition of mankind, is fufficient. Thefe feelings, it may be faid, are acquired by education and habit. By thefe caufes, it is true, our focial feelings are ftrengthened and confirmed; but their origin is coeval with the exiftence of the firft human mind. Let any man attend to the eyes, the features, and the geftures of a child upon the breaft, when another child

child is preſented to it; both inſtantly, previous to the poſſibility of inſtruction or habit, exhibit the moſt evident expreſſions of joy. Their eyes ſparkle, their features and geſtures demonſtrate, in the moſt unequivocal manner, a mutual attachment, and a ſtrong deſire of approaching each other, not with a hoſtile intention, but with an ardent affection, which, in that pure and uncontaminated ſtate of our being, does honour to human nature. When farther advanced, children who are ſtrangers to each other, though their ſocial appetite is equally ſtrong, diſcover a mutual ſhyneſs of approach. This ſhyneſs, or modeſty, however, is ſoon conquered by the more powerful inſtinct of aſſociation. They daily mingle and ſport together. Their natural affections, which, at that period, are ſtrong, and unbiaſſed by thoſe ſelfiſh and vicious motives which too often conceal and thwart the intentions of Nature, create warm friendſhips that frequently continue during their lives, and produce the moſt beneficial and cordial effects. When we thus ſee with our eyes, that the aſſociating principle appears at a period much more early than many of our other inſtincts, who will liſten to thoſe writers who chooſe to deny that man is, naturally, an aſſociating or gregarious animal?

With regard to the advantages we derive from aſſociation, a volume would not be ſufficient to enumerate them. Man, from the comparatively great number of inſtincts with which his mind is endowed, neceſſarily poſſeſſes a portion of the reaſoning faculty highly ſuperior to that of any other animal. He alone enjoys the power of communicating and expreſſing his ideas by articulate and artificial language. This ineſtimable prerogative is, perhaps, one of the greateſt ſecondary bonds of ſociety, and the greateſt ſource of improvement to the human intellect. Without artificial language, though Nature has beſtowed on every animal a mode of expreſſing its wants and deſires, its pleaſures and pains, what an humiliating figure would the human ſpecies exhibit, even upon the ſuppoſition that they did aſſociate? But, when language and aſſociation are conjoined, the human intellect, in the progreſs of time, arrives at a high degree of perfection.

perfection. Society gives riſe to virtue, honour, government, ſubordination, arts, ſcience, order, happineſs. All the individuals of a community conduct themſelves upon a regulated ſyſtem. Under the influence of eſtabliſhed laws, kings and magiſtrates, by the exerciſe of legal authority, encourage virtue, repreſs vice, and diffuſe, through the extent of their juriſdictions, the happy effects of their adminiſtration. In ſociety, as in a fertile climate, human talents germinate and are expanded; the mechanical and liberal arts flouriſh; poets, orators, hiſtorians, philoſophers, lawyers, phyſicians, and theologians, are produced. Theſe truths are pleaſant; and it were to be wiſhed that no evils accompanied them. But, through the whole extent of Nature, it ſhould appear, from our limited views, that good and evil, pleaſure and pain, are neceſſary and perpetual concomitants.

The advantages of ſociety are immenſe and invaluable. But the inconveniencies, hardſhips, injuſtice, oppreſſions, and cruelties, which too often originate from it, are great and lamentable. Even under the mildeſt and beſt regulated governments, animoſities, jealouſies, avarice, fraud, and chicane, are unfortunately never removed from our obſervation. In abſolute monarchies, and particularly in deſpotic governments, the ſcenes of private and of general calamity and diſtreſs are often too dreadful to be deſcribed. Notwithſtanding all theſe diſadvantages, however, any government is preferable to anarchy; and the comforts, pleaſures, and improvements, we receive from aſſociating with each other, overbalance all the evils to which ſociety gives riſe.

From an attentive obſervation of the manners and œconomy of animals, ſociety has been diſtinguiſhed into two kinds, which have been called *proper*, and *improper*.—1. *Proper Societies*, comprehend all thoſe animals who not only live together in numbers, but carry on certain operations which have a direct tendency to promote the welfare and happineſs of the community. 2. *Improper Societies*, include all thoſe animals who herd together, and love the company of each other, without carrying on any common operations.

1. *Pro-*

1. *Proper Societies.*—It is almoſt needleſs to remark that man holds the firſt rank in animal aſſociations of this kind. If men did not aſſiſt each other, no operation of any magnitude, or which could ſhow any great ſuperiority of talents above thoſe of the brute creation, could poſſibly be effected. A ſingle family, or even a few families united, like other carnivorous animals, might hunt their prey, and procure a ſufficient quantity of food. They might, like the bear, lodge in the cavities of trees; they might occupy natural caves in the rocks; they might even build huts with branches of trees and with turf, and cement theſe groſs materials with clay. This loweſt and moſt abject view of human nature is not exaggerated. It were to be wiſhed that this grovelling condition of mankind were fictitious, and that, in many regions of the globe, it did not, at this moment, exiſt. Theſe operations of men, when only acquainted with the mere rudiments of ſociety, indicate parts little ſuperior to thoſe of the brutes. Man, even in his moſt uninformed ſtate, poſſeſſes the inſtincts, or the germs, of every ſpecies of knowledge and of genius. But they muſt be cheriſhed, expanded, and brought gradually to perfection. It is by numerous and regularly-eſtabliſhed ſocieties alone that ſuch glorious exhibitions of human intellect can be produced. What is the hut of a ſavage when compared to the palace of a prince? or what his canoe when compared to a firſt-rate ſhip of war?

Next to the intelligence exhibited in human ſociety, that of the beavers is the moſt conſpicuous. Their operations in preparing, faſhioning, and tranſporting, the heavy materials for building their winter habitations, as formerly remarked *, are truly aſtoniſhing; and, when we read their hiſtory, we are apt to think that we are peruſing the hiſtory of man in a period of ſociety not inconſiderably advanced. It is only by the united ſtrength, and co-operation of numbers, that the beavers could be enabled to produce ſuch wonderful effects; for, in a ſolitary ſtate, as they at preſent appear in ſome northern parts of Europe, the beavers, like ſolitary ſavages, are timid and ſtupid animals. They neither aſſociate, nor attempt to conſtruct

* See above, page 281. &c. S.

conſtruct villages, but content themſelves with digging holes in the earth. Like men under the oppreſſion of deſpotic governments, the ſpirit of the European beavers is depreſſed, and their genius is extinguiſhed by terror, and by a perpetual and neceſſary attention to individual ſafety. The northern parts of Europe are now ſo populous, and the animals there are ſo perpetually hunted for the ſake of their furs, that they have no opportunity of aſſociating; of courſe, theſe wonderful marks of their ſagacity, which they exhibit in the remote and uninhabited regions of North-America, are no longer to be found. The ſociety of beavers is a ſociety of peace and of affection. They never quarrel or injure one another, but live together in different numbers, according to the dimenſions of particular cabins, in the moſt perfect harmony. The principle of their union is neither monarchical nor deſpotic: For the inhabitants of the different cabins, as well as thoſe of the whole village, ſeem to acknowledge no chief or leader whatever. Their aſſociation preſents to our obſervation a model of a pure and perfect republic, the only baſis of which is mutual and unequivocal attachment. They have no law but the law of love and of parental affection. Humanity prompts us to wiſh that it were poſſible to eſtabliſh republics of this kind among mankind. But the diſpoſitions of men have little affinity to thoſe of the beavers.

The hampſter, or German marmot, and ſome other quadrupeds of this kind, live in ſociety, and aſſiſt each other in digging and rendering commodious their ſubterraneous habitations. The operations of the marmots have already been deſcribed; and the nature of their ſociety, as they continue during the winter in a torpid ſtate, is either leſs known, or does not excite ſo much admiration as that of the beavers.

Pairing birds, in ſome meaſure, may be conſidered as forming proper ſocieties; becauſe, in general, the males and females mutually aſſiſt each other in building neſts and feeding their young. But this ſociety, except in the eagle-tribes, commonly continues no longer than their mutual offſpring are fully able to provide for themſelves.

None of the feathered tribes, as far as we know, unite in bodies, in order to carry on any operation common to the whole.

Neither do we learn from hiſtory that fiſhes ever aſſociate for the purpoſe of executing any common operation. Many of them, as herrings, ſalmons, &c. aſſemble in multitudes at particular ſeaſons of the year; but this aſſociation, to which they are impelled by inſtinct, has no common object; for each individual is ſtimulated to act in this manner by its own motives, and no general effect is produced by mutual exertions.

In proper ſocieties, each individual not only attends to his own preſervation and welfare, but all the members co-operate in certain laborious offices which produce many common advantages that could not otherwiſe be procured. In ſome ſocieties, the general principle of aſſociation and of mutual labour is purely inſtinctive, though, in many caſes, individuals learn, by obſervation and experience, to modify or accommodate this general principle according to particular accidents or circumſtances; ſome examples of which have already been given in the chapter upon inſtinct.

The inſect tribes furniſh many inſtances of proper ſocieties. The honey-bees not only labour in common with aſtoniſhing aſſiduity and art, but their whole attention and affections ſeem to center in the perſon of the queen or ſovereign of the hive. She is the baſis of their aſſociation and of all their operations. When ſhe dies by any accident, the whole community are inſtantly in diſorder. All their labours ceaſe. No new cells are conſtructed. Neither honey nor wax are collected. Nothing but perfect anarchy prevails, till a new queen or female is obtained. The government or ſociety of bees is more of a monarchical than of a republican nature. The whole members of the ſtate ſeem to reſpect and to be directed by a ſingle female. This fact affords a ſtrong inſtance of the force and wiſdom of Nature. The female alone is the mother of the whole hive, however numerous. Without her the ſpecies could not be continued. Nature, therefore, has endowed the reſt of the hive with a wonderful affection to

to their common parent. For the reception of her eggs, Nature impels them to conſtruct cells, and to lay up ſtores of proviſions for winter ſubſiſtence. Theſe operations proceed from pure inſtinctive impulſes. But every inſtinct neceſſarily ſuppoſes a degree of intellect, a ſubſtratum to be acted upon, otherwiſe no impulſe could be felt, and, of courſe, no action nor mark of intelligence could poſſibly be produced.

That the intelligence, the government, and the ſagacity of bees, have been frequently exaggerated, and as frequently miſunderſtood, no real philoſopher, or natural hiſtorian, will pretend to deny. But the late ingenious Count de Buffon, through the whole of his great work, betrays the ſtrongeſt inclination to deny that brutes, even thoſe which are eſteemed to be the moſt ſagacious, as the dog, the elephant, &c. not to mention the inferior tribes, as birds, fiſhes, and inſects, are endowed with the ſmalleſt portion of mind or intellect, but that all their movements, their expreſſions, their deſires, their arts, are ſolely the reſults of mechanical impulſes. The Count is peculiarly ſevere in his declamations againſt the ſagacity of the honey-bees, and the celebrators of their œconomy and manners. ‘ The genius of ſolitary bees,’ he remarks, ‘ is vaſtly inferior to that of the gregarious ſpecies ; and ‘ the talents of thoſe which aſſociate in ſmall troops are ‘ leſs conſpicuous than of thoſe that aſſemble in numerous ‘ bodies. Is not this alone ſufficient to convince us, that ‘ the *ſeeming genius* of bees is nothing but a reſult of *pure* ‘ *mechaniſm*, a combination of movements proportioned to ‘ numbers, an effect which appears to be complicated, only ‘ becauſe it depends on thouſands of individuals ? It muſt, ‘ therefore, be admitted, that bees, taken ſeparately, have ‘ leſs genius than the dog, the monkey, and moſt other ‘ animals : It will likewiſe be admitted, that they have leſs ‘ docility, leſs attachment, and leſs ſentiment ; and that ‘ they poſſeſs fewer qualities relative to thoſe of the human ſpecies. Hence we ought to acknowledge, that ‘ their apparent intelligence proceeds ſolely from the *multitude united*. This union, however, preſuppoſes not intellectual powers ; for they unite not from moral views :

‘ They

'They find themſelves together without their conſent. 'This ſociety, therefore, is a phyſical aſſemblage ordained by Nature, and has no dependence on knowledge or 'reaſoning. The mother bee produces at one time, and 'in the ſame place, ten thouſand individuals, which, 'though they were much more ſtupid than I have ſuppoſed them, would be obliged, ſolely for the preſervation of their exiſtence, to arrange themſelves into ſome 'order. As they all act againſt each other with equal 'forces, ſuppoſing their firſt movements to produce pain, 'they would ſoon learn to diminiſh this pain, or, in other 'words, to afford mutual aſſiſtance: They, of courſe, 'would exhibit an air of intelligence, and of concurring 'in the accompliſhment of the ſame end. A ſuperficial 'obſerver would inſtantly aſcribe to them views and talents which they by no means poſſeſs: He would explain 'every action: Every operation would have its particular 'motive, and prodigies of reaſon would ariſe without 'number; for ten thouſand individuals produced at one 'time, and obliged to live together, muſt all act in the 'very ſame manner; and, if endowed with feeling, they 'muſt acquire the ſame habits, aſſume that arrangement 'which is the leaſt painful, or the moſt eaſy to themſelves, 'labour in their hive, *return* after leaving it, &c. Hence 'the *origin* of the many wonderful talents aſcribed to bees, 'ſuch as their architecture, their geometry, their order, 'their foreſight, their patriotiſm, and, in a word, their 'republic, the whole of which, as I have *proved*, has no 'exiſtence but in the imagination of the obſerver *.'

That this mode of reaſoning ſhould have been ſeriouſly adopted by ſo great a literary character as that of Count de Buffon, is truly aſtoniſhing. The ſubſtance of the argument is, that ten thouſand bees, or other gregarious inſects, when brought into exiſtence at the ſame time, and in the ſame place, muſt neceſſarily, by the inconvenience or pain ariſing from mutual preſſure, aſſume an arrangement, and conſtruct commodious and artful habitations for the whole community. I hate polemical argumentation; and philoſophical abſurdities are the moſt difficult

* Tranſlation, vol. 3, page 285. S.

difficult to refute. If ten thousand butterflies, or any other flies, whose instinctive or mental powers differed from those of the bee, should be brought forth at the same time, and in the same place, which might be easily effected by collecting their chrysalids, Would these animals, from the inconveniencies or pain they might suffer by being crouded together, assume a proper arrangement, and build habitations suited to their mutual comfort and preservation? No. If not allowed to escape from their present situation, they would suffocate each other; and, if any of them were permitted to get out of their prison, instead of returning, like the bees, they would avoid it with as much horror as a person who had made his escape from the Black Hole of Calcutta. No declamatory reasoning, however specious, will ever change the nature of truth. Without some portion of intellect, or what is synonimous, of mental powers, How should the different kinds of bees in the same hive be induced to perform so many different operations? While some are busily employed at home in the construction of cells, others are equally industrious in the fields collecting materials for carrying on the work. They are no sooner relieved from their load by their companions and fellow-labourers in the hive, than they again repair to the fields, and, with persevering industry, fly from flower to flower till they have amassed another load of materials, which they immediately transport to the hive. In this laborious office they persist for many hours every day when the weather permits. Will any man pretend to assert, that these, and many similar operations performed by bees, are the results of mechanical impulses *? Are bees, when collecting honey, and the farina of flowers, at great distances from the hive, compelled, by the mechanical pressure of multitudes, to assume a certain arrangement, and all of them to act in the same manner? Can any animal be possessed of more liberty, or be more free from mechanical restraint, than a bee while roaming at large in the fields? Besides, What should force a bee, while wallowing in luxury,

* For several curious operations of bees, which it will be difficult to reconcile with any principles of mechanism, the reader may consult page 302, &c. S.

luxury, to return ſo repeatedly to the hive with no other view than to feed its companions, or to furniſh them with materials for their work? Here every idea of mechanical impulſe is utterly excluded. That bees, as well as other animals, are actuated by motives, or impulſes, it is willingly allowed. But theſe are not mechanical impulſes. They are the wiſe and irreſiſtible impulſes of Nature upon their minds. If bees did not aſſociate, and mutually aſſiſt one another in their various operations, the ſpecies would ſoon be anihilated. Not one of them, it is probable, would ſurvive the firſt winter. But Nature, ever ſolicitous for the preſervation of her productions, has endowed their minds with an aſſociating principle, and with inſtincts which ſtimulate them to perform all thoſe wonderful operations that are neceſſary for the exiſtence of individuals, and the continuation of the ſpecies.

What are called the *common* caterpillars afford an inſtance of proper aſſociation. About the middle of ſummer, a butterfly depoſits from three to four hundred eggs on the leaf of a tree, from each of which, in a few days, a young caterpillar proceeds. They are no ſooner hatched than they begin to form a common habitation. They ſpin ſilken threads, which they attach to one edge of the leaf, and extend them to the other. By this operation they make the two edges of the leaf approach each other, and form a cavity reſembling a hammock. In a ſhort time, the concave leaf is completely roofed with a covering of ſilk. Under this tent the animals live together in mutual friendſhip and harmony. When not diſpoſed to eat or to ſpin, they retire to their tent. It requires ſeveral of theſe habitations to contain the whole. According as the animals increaſe in ſize, the number of their tents is augmented. But theſe are only temporary and partial lodgements, conſtructed for mutual conveniency, till the caterpillars are in a condition to build one more ſpacious, and which will be ſufficient to contain the whole. After gnawing one half of the ſubſtance of ſuch leaves as happen to be near the end of ſome twig or ſmall branch, they begin their great work. In conſtructing this new edifice

edifice or neſt, the caterpillars encruſt a conſiderable part of the twig with white ſilk. In the ſame manner, they cover two or three of ſuch leaves as are neareſt to the termination of the twig. They then ſpin ſilken coverings of greater dimenſions, in which they incloſe the two or three leaves together with the twig. The neſt is now ſo ſpacious that it is able to contain the whole community, every individual of which is employed in the common labour. Theſe neſts are too frequently ſeen, in autumn, upon the fruit-trees of our gardens. They are ſtill more expoſed to obſervation in winter, when the leaves, which formerly concealed many of them, are fallen. They conſiſt of large bundles of white ſilk and withered leaves, without any regular or conſtant form. Some of them are flat, and others roundiſh; but none of them are deſtitute of angles. By different plain coverings extended from the oppoſite ſides of the leaves and of the twig, the internal part of the neſt is divided into a number of different apartments. To each of theſe apartments, which ſeem to be very irregular, there are paſſages by which the caterpillars can either go out in queſt of food, or retire in the evening, or during rainy weather. The ſilken coverings, by repeated layers, become at laſt ſo thick and ſtrong, that they reſiſt all the attacks of the wind, and all the injuries of the air, during eight or nine months. About the beginning of October, or when the froſt firſt commences, the whole community ſhut themſelves up in the neſt. During the winter they remain immoveable, and ſeemingly dead. But, when expoſed to heat, they ſoon diſcover ſymptoms of life, and begin to creep. In this country, they ſeldom go out of the neſt till the middle or end of April. When they ſhut themſelves up for the winter, they are very ſmall; but, after they have fed for ſome days in ſpring upon the young and tender leaves, they find the neſt itſelf, and all the entrances to it, too ſmall for the increaſed ſize of their bodies. To remedy this inconveniency, theſe diſguſting reptiles know how to enlarge both the neſt and its paſſages by additional operations accommodated to their preſent ſtate. Into theſe new lodgings they retire when they want to repoſe,

to ſcreen themſelves from the injuries of the weather, or to caſt their ſkins. In fine, after caſting their ſkins ſeveral times, the time of their diſperſion arrives. From the beginning to near the end of June, they lead a ſolitary life. Their ſocial diſpoſition is no longer felt. Each of them ſpins a pod of coarſe browniſh ſilk. In a few days they are changed into chryſalids; and, in eighteen or twenty days more, they are transformed into butterflies.

Caterpillars of another ſpecies, which Reaumur diſtinguiſhes by the appellation of the *proceſſionary caterpillar*, live in ſociety till their transformation into flies. Theſe caterpillars are of the hairy kind, and are of a reddiſh colour. They inhabit the oak, and feed upon its leaves. When very young, they have no fixed or general habitation. But, after they have acquired about one half of their natural ſize, they aſſemble together, and conſtruct a neſt ſufficient to accommodate the whole. The neſts of theſe caterpillars are attached to the trunks of the oak, and are ſituated ſometimes near the earth, and ſometimes ſeven or eight feet above its ſurface. They conſiſt of different ſtrata, or layers, of ſilk, which are ſpun by the united labour of the whole community. Their figure is neither ſtriking nor uniform. On the part of the oak to which they are fixed they form a protuberance ſimilar to thoſe knots which are ſeen upon trees. This protuberance ſometimes reſembles a ſegment of a circle, and ſometimes it is three or four times longer than it is broad. Some of theſe neſts are from eighteen to twenty inches long, and from five to ſix inches wide. About the middle of their convexity, they often riſe more than four inches above the ſurface of the tree. Between the trunk of the tree and the layers of ſilk a ſingle hole is left, to allow the animals to go out in queſt of food, and to retire into the neſt after they are ſatiated. Notwithſtanding the great bulk of theſe neſts, and though there are often three or four of them upon the ſame tree, and never elevated above the height of diſtinct viſion, they are not eaſily perceived; for the ſilk of which they are compoſed is cinereous, and reſembles, in colour, thoſe moſſes with which the trunk of the oak is generally covered.

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The inhabitants of a neſt, which are numerous, march out, about the ſetting of the ſun, to forage, under the conduct of a chief or leader, all whoſe movements they uniformly follow. The order they obſerve is ſingular. The firſt rank conſiſts of ſingle animals, the ſecond of two, the third of three, the fourth of four, and ſometimes more. In this manner they proceed in queſt of food with all the regularity of diſciplined troops. The chief or leader has no marks of pre-eminence; for any individual that happens firſt to iſſue from the neſt, from that circumſtance alone, becomes the leader of an expedition. After making a full repaſt upon the neighbouring leaves, they return to the neſt in the ſame regular order; and this practice they continue during the whole period of their exiſtence in the caterpillar ſtate. It was from this ſtrange regularity of movement that Reaumur, with much propriety, denominated theſe animals *proceſſionary* caterpillars. When arrived at maturity, each individual ſpins a ſilken pod, is converted into a chryſalis, and afterwards aſſumes the form of a butterfly. This laſt transformation breaks all the bonds of their former aſſociation, and the female flies depoſit their eggs, which, when hatched, produce new colonies, who exhibit the ſame œconomy and manners.

There are ſeveral ſpecies of caterpillars who are real republicans, and whoſe diſcipline, manners, and genius, are equally diverſified as thoſe of the inhabitants of different nations and climates. Some, like particular ſavages, conſtruct a kind of hammocks, in which they take their victuals, repoſe, and ſpend their lives till the period of their transformation. Others, like the Arabs and Tartars, conſtruct and live in ſilken tents, and, after conſuming the neighbouring herbage, they leave their former habitations, and encamp on freſh paſture. Under theſe tents they are not only protected from the injuries of the weather, but they repoſe in them when ſick, or in a ſtate of inactivity. They go out of their tents at particular times in queſt of food, and often to conſiderable diſtances; but they never loſe their way back. It is not by ſight that they are directed with ſo much certainty to their abodes.

abodes. Nature has furniſhed them with another guide for regaining their habitations. We pave our ſtreets with ſtones; but the caterpillars cover all their roads with ſilken threads. Theſe threads make white tracks, which are often more than a ſixth of an inch wide. It is by following theſe ſilken tracks, however complicated, that the caterpillars never miſs their neſts. If the road is broke by a man's finger drawn along it, or by any other accident, the caterpillars are greatly embarraſſed. They ſtop ſuddenly at the interrupted ſpace, and exhibit every mark of fear and of diffidence. Here the march ſtops, till an individual, more bold or more impatient than his companions, traverſes the gap. In his paſſage, he leaves behind him a thread of ſilk, which ſerves as a bridge or conductor to the next that follows. By the progreſſion of numbers, each of which ſpins a thread, the breach is ſoon repaired. We cannot ſuppoſe that theſe ſtupid animals cover their roads to prevent their wandering. But they never wander, becauſe their roads are covered with ſilk. In this, as well as in many other inſtances, Nature obliges animals to embrace the moſt effectual means of ſelf-preſervation, and even of conveniency, without their perceiving the utility of their own operations. The caterpillars, whoſe manners we have been deſcribing, ſpin almoſt continually, becauſe they are continually obliged to evacuate a ſilky matter, ſecreted from their food by veſſels deſtined for that purpoſe, and included in their inteſtines. In obeying this call of Nature, they effectually ſecure their retreat to their neſts, and perhaps their exiſtence. It may be ſaid, that caterpillars aſſociate for no other reaſon but becauſe they are all produced at the ſame time from eggs depoſited near each other. But many other ſpecies of caterpillars, who are brought to life in the very ſame circumſtances, never aſſociate or act in concert in the performance of any mutual labour. The ſilk-worms afford a familiar example. It is true, they ſpontaneouſly remain aſſembled in the ſame place, which is of great advantage to manufacture. But the individuals of other ſpecies diſperſe immediately after birth, and never re-unite. Spiders, when newly hatched, begin with

ſpinning a web in common; but they ſoon terminate this aſſociation by devouring one another.

As caterpillars do not engender till they arrive at the butterfly ſtate, their aſſociations have no reſpect to the rearing or education of young. Self-preſervation and individual conveniency are the only bonds of their union. A perfect equality reigns among them, without any diſtinction of ſex, or even of ſize. Each takes his ſhare of the common labour; and the whole ſociety, which conſtitutes but one family, is the genuine iſſue of the ſame mother.

The aſſociation and œconomy of the common ants merit ſome attention. With wonderful induſtry and activity they collect materials for the conſtruction of their neſt. They unite in numbers, and aſſiſt each other in excavating the earth, and in tranſporting to their habitation bits of ſtraw, ſmall pieces of wood, and other ſubſtances of a ſimilar kind, which they employ in lining and ſupporting their ſubterraneous galleries. The form of their neſt or hill is ſomewhat conical, and, of courſe, the water, when it rains, runs eaſily off, without penetrating their abode. Under this hill there are many galleries or paſſages which communicate with each other, and reſemble the ſtreets of a ſmall city.

The ants not only aſſociate for the purpoſe of conſtructing a common habitation, but for cheriſhing and protecting their offspring. Every perſon muſt have often obſerved, when part of a neſt is ſuddenly expoſed, their extreme ſolicitude for the preſervation of their chryſalids or nymphs, which often exceed the ſize of the animals themſelves. With amazing dexterity and quickneſs the ants tranſport their nymphs into the ſubterraneous galleries of the neſt, and place them beyond the reach of any common danger. The courage and fortitude with which they defend their young is no leſs aſtoniſhing. The body of an ant was cut through the middle, and, after ſuffering this cruel treatment, ſo ſtrong was its parental affection, with its head, and one half of the body, it carried off eight or ten nymphs. They go to great diſtances in ſearch of

proviſions.

provifions. Their roads, which are often winding and involved, all terminate in the neft.

The wifdom and forefight of the ants have been celebrated from the remoteft antiquity. It has been afferted and believed, for near three thoufand years, that they lay up magazines of provifions for the winter, and that they even cut off the germ of the grain to prevent it from fhooting. But the ancients were never famed for accurate refearches into the nature and operations of infects. Thefe fuppofed magazines could be of no ufe to the ants; for, like the marmots and dormice, they fleep during the winter. A very moderate degree of cold is fufficient to render them torpid. In fact, it is now well known that they amafs no magazines of provifions. The grains which, with fo much induftry and labour, they carry to their neft, are not intended to be food to the animals, but, like the bits of ftraw and wood, are employed as materials in the conftruction of their habitation.

2. *Improper Societies.*—Many animals are gregarious, though they unite not with a view to any joint operation, fuch as conftructing common habitations, or mutually and indifcriminately nourifhing and protecting the offfpring produced by the whole fociety. But, even among animals of this defcription, there are motives or bonds of affociation, and, in many inftances, they mutually affift and defend each other from hoftile affaults.

The ox is a gregarious animal. When a herd of oxen are pafturing in a meadow, if a wolf makes his appearance, they inftantly form themfelves in battle array, and prefent their united horns to the enemy. This warlike difpofition often intimidates the wolf, and obliges him to retire.

In winter, the hinds and young ftags affociate, and form herds, which are always more numerous in proportion to the feverity of the weather. One bond of their fociety feems to be the advantage of mutual warmth derived from each other's bodies. In fpring they difperfe, and the hinds conceal themfelves in the forefts, where they bring forth their young. The young ftags, however, continue

continue together; they love to browſe in company; and neceſſity alone forces them to ſeparate.

The Count de Buffon repreſents ſheep as ſtupid creatures, which are incapable of defending themſelves againſt the attacks of any rapacious animal. He maintains that the race muſt long ago have been extinguiſhed, if man had not taken them under his immediate protection. But Nature has furniſhed every ſpecies of animated beings with weapons and arts of defence which are ſufficient for individual preſervation as well as the continuation of the kind. Sheep are endowed with a ſtrong aſſociating principle. When threatened with an attack, like ſoldiers, they form a line of battle, and boldly face the enemy. In a natural ſtate, the rams conſtitute one half of the flock. They join together and form the front. When prepared in this manner for repelling an aſſault, no lion or tiger can reſiſt their united impetuoſity and force.

A family of hogs, when in a ſtate of natural liberty, never ſeparate till the young have acquired ſtrength ſufficient to repel the wolf. When a wolf threatens an attack, the whole family unite their forces, and bravely defend each other.

The wild dogs of Africa hunt in packs, and carry on a perpetual war againſt other rapacious animals. The jackals of Aſia and Africa likewiſe hunt in packs. But, though animals of this kind mutually aſſiſt each other in killing prey, individual advantage is the chief, if not the only, bond of this temporary union.

Another kind of ſociety is obſervable among domeſtic animals. Horſes and oxen, when deprived of companions of their own ſpecies, aſſociate, and diſcover a viſible attachment. A dog and an ox, or a dog and a cow, when placed in certain circumſtances, though the ſpecies are remote, and even hoſtile, acquire a ſtrong affection for each other. The ſame kind of aſſociation takes place between dogs and cats, between cats and birds, &c. If domeſtic animals had a ſtrong averſion to one another, man could not derive ſo many advantages from them. Horſes, oxen, ſheep, &c. by browſing promiſcuouſly together, augment and meliorate the common paſture. By living

living under the ſame roof, and feeding in common, this aſſociating principle is ſtrengthened and modified by habit, which often commences immediately after birth. A ſingle horſe confined in an encloſure, diſcovers every mark of uneaſineſs. He becomes reſtleſs, neglects his food, and breaks through every fence in order to join his companions in a neighbouring field. Oxen and cows will not fatten in the fineſt paſture, if they are deprived of ſociety.

From the facts and remarks contained in this chapter, it ſeems to be evident, that the principle of aſſociation in man, as well as in many other animals, is purely inſtinctive; and that this principle may be ſtrengthened and modified by the numberleſs advantages derived from it; by imitation, by habit, and by many other circumſtances.

CHAPTER XVII.

Of the Docility of Animals.

OF all animals capable of culture, man is the moſt ductile. By inſtruction, imitation, and habit, his mind may be moulded into any form. It may be exalted by ſcience and art to a degree of knowledge, of which the vulgar and uninformed have not the moſt diſtant conception. The reverſe is melancholy. When the human mind is left to its own operations, and deprived of almoſt every opportunity of ſocial information, it ſinks ſo low, that it is nearly rivalled by the moſt ſagacious brutes. The natural ſuperiority of man over the other animals, as formerly remarked, is a neceſſary reſult of the great number of inſtincts with which his mind is endowed. Theſe inſtincts are gradually unfolded, and produce, after a mature age, reaſon, abſtraction, invention, ſcience.

ſcience. To confirm this truth, it would be fruitleſs to have recourſe to metaphyſical arguments, which generally miſlead and bewilder human reaſon. A diligent attention to the actual operations of Nature is ſufficient to convince any mind that is not warped and deceived by popular prejudice, the fetters of authorities, as they are called, whether ancient or modern, or by the vanity of ſupporting preconceived opinions and favourite theories. Let any man reflect on the progreſs of children from birth to manhood. At firſt, their inſtincts are limited to obſcure ſenſations, and to the performance of a few corporeal actions, to which they are prompted, or rather compelled, by certain ſtimulated impulſes unneceſſary to be mentioned. In a few months, their ſenſations are perceived to be more diſtinct, their bodily actions are better directed, new inſtincts are unfolded, and they aſſume a greater appearance of rationality and of mental capacity. When ſtill farther advanced, and after they have acquired ſome uſe of language, and ſome knowledge of natural objects, they begin to reaſon; but their reaſonings are feeble, and often prepoſterous. In this manner they uniformly proceed in improvement till they are actuated by the laſt inſtinct, at or near the age of puberty. After this period, they reaſon with ſome degree of perſpicuity and juſtneſs. But, though their whole inſtincts are now unfolded and in action, every power of their minds requires, previous to its utmoſt exertions, to be agitated and poliſhed by an examination of a thouſand natural and artificial objects, by the experience and obſervations of thoſe with whom they aſſociate, by public or private inſtruction, by ſtudying the writings of their predeceſſors and cotemporaries, and by their own reflections, till they arrive at the age of thirty-five. Previous to that period, much learning may have been acquired, much genius may have been exerted; but, before that time of life, judgment, abſtraction, and the reaſoning faculty, are not fully matured. This progreſs is the genuine operation of Nature, and the gradual ſource of human ſagacity and mental powers. The ſame progreſs is to be obſerved in the powers of the body. It arrives, indeed, ſooner at perfection

fection than the mind. But, if the progreſs of the mind greatly preceded that of the body, what a miſerable and aukward figure would human beings, at an early period of their exiſtence, exhibit? Active and vigorous minds, ſtimulated to command what the organs of their bodies were unable to obey, would produce peeviſhneſs, anger, regret, and every diſtreſſing paſſion.

The bodies of men, though not ſo ductile as their minds, are capable, when properly managed by early culture, of wonderful exertions. Men, accuſtomed to live in poliſhed ſocieties, have little or no idea of the activity, the courage, the patience, and the perſevering induſtry, of ſavages, when ſimply occupied in hunting wild animals for food to themſelves and their families. The hunger, the fatigue, the hardſhips, which they not only endure, but deſpiſe, with fortitude, would amaze and terrify the imagination of any civilized European.

Beſide man, many other animals are capable of being inſtructed. The ape-kind, and eſpecially the larger ſpecies of them, imitate the actions of men without any inſtruction. This imitation they are enabled to perform with the greater exactneſs, on account of their ſtructure. The orang-outang, a native of the ſouthern regions of Africa and India, is as tall and as ſtrong as a man. He has no tail. His face is flat. His arms, hands, toes, and nails, are perfectly ſimilar to ours. He walks conſtantly on end; and the features of his viſage make a near approach to thoſe of the human countenance. He has a beard on his chin, and no more hair on his body than men have when in a ſtate of nature. He knows how to bear arms, to attack his enemies with ſtones, and to defend himſelf with a club. Of all the apes, the orang-outang, or *wild man*, as he is called by the Indians, has the greateſt reſemblance to man, both in the ſtructure of his body and in his manners. There are two ſuppoſed ſpecies of orang-outang, a larger and a ſmaller. The latter has been ſeveral times brought to Europe, and accurate deſcriptions have been given both of his external and internal parts. But, with regard to the larger kind, who is ſaid to exceed the ordinary ſtature of man, we have nothing

thing to rely on but the relations of travellers. Bontius, who was chief phyſician in Batavia, affirms expreſsly, that he ſaw, with admiration, ſeveral individuals of this ſpecies walking on their two feet. Among others, he remarked a female, who ſeemed to have a ſenſe of modeſty, who covered her face with her hands when men approached her with whom ſhe was unacquainted, who wept, groaned, and ſeemed to want nothing of humanity but the faculty of ſpeech *. Many other ſurpriſing actions performed by this animal are recorded by different voyagers, which it is unneceſſary to repeat, eſpecially as we have a ſufficient number of facts atteſted by unequivocal evidence. The Count de Buffon, with much probability, conſiders what are called the large and ſmall orang-outangs to be the ſame ſpecies of animals; for thoſe hitherto brought to Europe were very young, and had not acquired one half of their ſtature.

'The orang-outang,' ſays Buffon, 'which I ſaw, walked always on two feet, even when carrying things of conſiderable weight. His air was melancholy, his movements meaſured, his diſpoſitions gentle, and very different from thoſe of other apes. He had neither the impatience of the Barbary ape, the maliciouſneſs of the baboon, nor the extravagance of the monkeys. It may be alledged that he had the benefit of inſtruction; but the apes, which I ſhall compare with him, were educated in the ſame manner. Signs and words were alone ſufficient to make our orang-outang act: But the baboon required a cudgel, and the other apes a whip; for none of them would obey without blows. I have ſeen this animal preſent his hand to conduct the people who came to viſit him, and walk as gravely along as if he had formed a part of the company. I have ſeen him ſit down at table, unfold his towel, wipe his lips, uſe a ſpoon or a fork to carry the victuals to his mouth, pour his liquor into a glaſs, and make it touch that of the perſon who drank along with him. When invited to drink tea, he brought a cup and a ſaucer, placed them on the table, put in ſugar, poured out the tea, and al-
'lowed

* Jac. Bont. Hiſt. Nat. Ind. cap. 32. S.

'lowed it to cool before he drank it. All theſe actions he 'performed without any other inſtigation than the ſigns 'or verbal orders of his maſter, and often of his own ac- 'cord. He did no injury to any perſon. He even ap- 'proached company with circumſpection, and preſented 'himſelf as if he wanted to be careſſed. He was very 'fond of dainties, which every body gave him: And, as 'his breaſt was diſeaſed, and he was afflicted with a teaz- 'ing cough, this quantity of ſweatmeats undoubtedly con- 'tributed to ſhorten his life. He lived one ſummer in 'Paris, and died in London the following winter. He 'eat almoſt every thing; but preferred ripe and dried 'fruits to all other kinds of food. He drank a little 'wine; but ſpontaneouſly left it for milk, tea, or other 'mild liquors *.'

M. de la Broſſe purchaſed two orang-outangs from a Negro, whoſe age exceeded not twelve months. 'Theſe 'animals,' he remarks, 'have the inſtinct of ſitting at 'table like men. They eat every kind of food without 'diſtinction. They uſe a knife, a fork, or a ſpoon, to cut 'or lay hold of what is put upon their plate. They drink 'wine and other liquors. We carried them aboard. At 'table, when they wanted any thing, they made them- 'ſelves be underſtood by the cabin-boy: And, when the 'boy refuſed to give them what they demanded, they 'ſometimes became enraged, ſeized him by the arm, bit, 'and threw him down.—The male was ſeized with ſick- 'neſs in the road. He made himſelf be attended as a 'human being. He was even twice bled in the right 'arm: And, whenever he found himſelf afterwards in 'the ſame condition, he held out his arm to be bled, as 'if he knew that he had formerly received benefit from 'that operation.'

We are informed by Francis Pyrard, 'that, in the pro- 'vince of Sierra-Leona, there is a ſpecies of animals cal- 'led *baris* (the orang-outang), who are ſtrong and well 'limbed, and ſo induſtrious, that, when properly trained 'and fed, they work like ſervants; that they generally 'walk on the two hind-feet; that they pound any ſub-

* Buffon, vol. 8. page 86. Tranſl. S.

'ſtances in a mortar; that they go to bring water from 'the river in ſmall pitchers, which they carry full on their 'heads. But, when they arrive at the door, if the pitch-'ers are not ſoon taken off, they allow them to fall; and, 'when they perceive the pitcher overturned and broken, 'they weep and lament *.' With regard to the educa-tion of theſe animals, the teſtimony of Schoutton cor-reſponds with that of Pyrard. 'They are taken,' ſays he, 'with ſnares, taught to walk on their hind-feet, and 'to uſe their fore-feet as hands in performing different 'operations, as rinſing glaſſes, carrying drink round the 'company, turning a ſpit,' &c.†. Guat informs us, that he 'ſaw at Java a very extraordinary ape. It was a fe-'male. She was very tall, and often walked erect on her 'hind-feet. On theſe occaſions, ſhe concealed with her 'hands the parts which diſtinguiſh the ſex.—She made 'her bed very neatly every day, lay upon her ſide, and 'covered herſelf with the bed-clothes.—When her head 'ached, ſhe bound it up with her handkerchief; and it 'was amuſing to ſee her thus hooded in bed. I could re-'late many other little articles which appeared to be ex-'tremely ſingular. But I admired them not ſo much as 'the multitude; becauſe, as I knew the deſign of bring-'ing her to Europe to be exhibited as a ſhew, I was in-'clined to think that ſhe had been *taught* many of theſe 'monkey tricks, which the people conſidered as being 'natural to the animal. She died in our ſhip, about the 'latitude of the Cape of Good Hope. The figure of this 'ape had a very great reſemblance to that of man ‡.'

We have now enumerated the principal facts regarding this extraordinary animal, which have been related by voyagers of credit, and by thoſe who have ſeen and ex-amined him in Europe; and ſhall only remark, that, not-withſtanding the great ſimilarity of his ſtructure and or-gans to thoſe of the human ſpecies, his genius and talents ſeem to be very limited. The form of his body enables him to imitate every human action. But, though he has the

* Voyages de Francois Pyrard, tom 2. page 331. S.
† Voyages de Schoutton, aux Indes Orientales. S.
‡ Voyages de Fran. le Guat, tom. 2. page 96. S.

the organs of ſpeech, he is deſtitute of articulate language. If, however, he were domeſticated, and proper pains beſtowed for inſtructing him, he might unqueſtionably be taught to articulate. But, ſuppoſing this point to be obtained, if he remained incapable of reflection, if he was unable to comprehend the meaning of words, or to diſcover by his expreſſions a degree of intellect greatly ſuperior to that of the brute creation, which I imagine would be the caſe, he could never, as ſome authors have held forth, be exalted to the diſtinguiſhed rank of human beings.

Of all quadrupeds, of whoſe hiſtory and manners we have any proper knowledge, the elephant is moſt remarkable both for docility and underſtanding. Though his ſize is enormous, and his members rude and diſproportioned, which give him, at firſt ſight, the aſpect of dulneſs and ſtupidity, his genius is great, and his ſagacious manners, and his ſedate and collected deportment, are almoſt incredible. He is the largeſt and ſtrongeſt of all terreſtrial animals. Though naturally brave, his diſpoſitions are mild and peaceable. He is an aſſociating animal, and ſeldom appears alone in the foreſts. When in danger, or when they undertake a depredatory expedition into cultivated fields, the elephants aſſemble in troops. The oldeſt takes the lead; the next in ſeniority brings up the rear; and the young and the feeble occupy the center. In the foreſts and ſolitudes they move with leſs precaution; but never ſeparate ſo far aſunder as to render them incapable of affording each other mutual aſſiſtance when danger approaches. A troop of elephants conſtitutes a moſt formidable band. Wherever they march, the foreſt ſeems to fall before them. They bear down the branches upon which they feed; and, if they enter an incloſure, they ſoon deſtroy all the labours of the huſbandman. Their invaſions are the more tremendous, as there is hardly any means of repelling them; for, to attack a troop, when thus united, would require a little army. It is only when one or two elephants happen to linger behind the reſt, that the hunters dare exert their art and ingenuity in making an attack; for any attempt to diſturb the troop would

would certainly prove fatal to the aſſailants. When an inſult is offered, the elephants inſtantly move forward againſt the offender, toſs him in the air with their tuſks, and afterwards trample him to pieces under their feet, or rather pillars of fleſh and bone. Let not the character of this noble and majeſtic animal, however, be miſrepreſented. With force and dignity he reſents every affront; but, when not diſturbed by petulance or actual injury, he never ſhows an hoſtile intention either againſt man or any other animal. Elephants live entirely on vegetables, and have no thirſt for blood. Such is their ſocial and generous diſpoſition, that, when an individual chances to meet with a luxurious ſpot of paſture, he immediately calls to his companions, and invites them to partake of his good fortune.

The elephant poſſeſſes all the ſenſes in perfection: But, in the ſenſe of touching, he excels all the brute creation. His trunk is the chief inſtrument of this ſenſe. In an elephant of fourteen feet high, the trunk is about eight feet long, and five feet and an half in circumference at the baſe. It is a large fleſhy tube, divided through its whole extent by a ſeptum or partition. It is capable of motion in every direction. The animal can ſhorten or lengthen it at pleaſure. It anſwers every purpoſe of a hand; for it graſps large objects with great force, and its extremity can lay hold of a ſixpence, or even of a pin. The trunk of the elephant affords him the ſame means of addreſs as the ape. It ſerves the purpoſes of an arm and a hand. By this inſtrument, the elephant conveys large or ſmall bodies to his mouth, places them on his back, embraces them faſt, or throws them forcibly to a diſtance. In a ſtate of nature and perfect freedom, the diſpoſitions of the elephant are neither ſanguinary nor ferocious. They are gentle creatures, and never exert their ſtrength, or employ their weapons, but in defending themſelves or protecting their companions. Even when deprived of the inſtruction of men, they poſſeſs the ſagacity of the beaver, the addreſs of the ape, and the acuteneſs of the dog. To theſe mental talents are added the advantages of amazing bodily ſtrength, and the experience and know-

ledge

ledge he acquires by living at leaſt two centuries. With his trunk he tears up trees. By a puſh of his body he makes a breach in a wall. To this prodigious ſtrength he adds courage, prudence, and coolneſs of deportment. As he never makes an attack but when he receives an injury, he is univerſally beloved; and all animals reſpect, becauſe none have any reaſon to fear him. In all ages, men have entertained a veneration for this moſt magnificent and ſagacious of terreſtrial creatures. The ancients regarded him as a miracle of Nature, and he is, in reality, one of her greateſt efforts. But they have greatly exaggerated his faculties. Without heſitation, they have aſcribed to him high intellectual powers and moral virtues. Pliny, Ælian, Plutarch, and other authors of a more modern date, have beſtowed on the elephant not only rational manners, but an innate religion, a kind of daily adoration of the ſun and moon, the uſe of ablution before worſhip, a ſpirit of divination, piety toward heaven and their fellow-creatures, whom they aſſiſt at the approach of death, and, after their deceaſe, bedew them with tears, and cover their bodies with earth.

When tamed and inſtructed by man, the elephant is ſoon rendered the mildeſt and moſt obedient of all domeſtic animals. He loves his keeper, careſſes him, and anticipates his commands. He learns to comprehend ſigns, and even to underſtand the expreſſion of ſounds. He diſtinguiſhes the tones of command, of anger, and of approbation, and regulates his actions by his perceptions. The voice of his maſter he never miſtakes. His orders are executed with alacrity, but without any degree of precipitation. His movements are always meaſured and ſedate, and his character ſeems to correſpond with the gravity of his maſs. To accommodate thoſe who mount him, he readily learns to bend his knees. With his trunk he ſalutes his friends, uſes it for raiſing burdens, and aſſiſts in loading himſelf. He loves to be clothed, and ſeems to be proud of gaudy trappings. In the ſouthern regions, he is employed in drawing waggons, ploughs, and chariots. 'I was eye-witneſs,' ſays P. Philippe, 'to 'the following facts. At Goa, there are always ſome ele-

'phants

'phants employed in the building of ſhips. I one day 'went to the ſide of the river, near which a large ſhip 'was building in the city of Goa, where there is a large 'area filled with beams for that purpoſe. Some men tie 'the ends of the heavieſt beams with a rope, which is 'handed to the elephant, who carries it to his mouth, 'and, after twiſting it round his trunk, draws it, with- 'out any conductor, to the place where the ſhip is build- 'ing, though it had only once been pointed out to him. 'He ſometimes drew beams ſo large that more than twenty 'men would have been unable to move. But, what ſur- 'priſed me ſtill more, when other beams obſtructed the 'road, he elevated the ends of his own beams, that they 'might run eaſily over thoſe which lay in his way. Could 'the moſt enlightened man do more *?' When at work, the elephant draws equally, and, if properly managed, never turns reſtive. The man who conducts the animal generally rides on his neck, and employs a hooked iron rod, or a bodkin, with which he pricks the head or ſides of the ears, in order to puſh the creature forward, or to make him turn. But words are commonly ſufficient. The attachment and affection of the elephant are ſome-times ſo ſtrong and durable that he has been known to die of grief, when, in an unguarded paroxyſm of rage, he had killed his guide.

Before the invention of gun-powder, elephants were employed in war by the African and Aſiatic nations. 'From time immemorial,' ſays Schouten, 'the Kings of 'Ceylon, of Pegu, and of Aracan, have uſed elephants 'in war. Naked ſabres were tied to their trunks, and 'on their backs were fixed ſmall wooden caſtles, which 'contained five or ſix men armed with javelins, and other 'weapons †.' The Greeks and Romans, however, ſoon became acquainted with the nature of theſe monſtrous warriors. They opened their ranks to let the animals paſs, and directed all their weapons, not againſt the elephants, but their conductors. Since fire has now become the ele-ment of war, and the chief inſtrument of deſtruction, elephants, who are terrified both at the flame and noiſe, would

* Voyage d'Orient. pag. 367. S.

† Voyage de Schouten, pag. 32. S.

would be more dangerous than uſeful in our modern battles. The Indian Kings, however, ſtill arm elephants in their wars. In Cochin, and other parts of Malabàr, all the warriors who fight not on foot are mounted on elephants *. The ſame practice obtains in Tonquin, Siam, and Pegu. In theſe countries, the kings and nobles at public feſtivals are always preceded and followed by numerous trains of elephants, pompouſly adorned with pieces of ſhining metal, and clothed with rich garments. Their tuſks are ornamented with rings of gold and ſilver; their ears and cheeks are painted with various colours; they are crowned with garlands; and a number of ſmall bells are fixed to different parts of their bodies. They delight in gaudy attire; for they are chearful and careſſing in proportion to the number and ſplendour of their ornaments. The Aſiatics, who were very anciently civilized, perceiving the ſagacity and docility of the elephant, educated him in a ſyſtematic manner, and modified his diſpoſitions according to their own manners, and the uſeful labours in which his ſtrength and dexterity could be employed.

A domeſtic elephant performs more labour than could be accompliſhed by ſix horſes; but he requires much care and a great deal of food. He is ſubject to be overheated, and muſt be led to the water twice or thrice a-day. He eaſily learns to bathe himſelf. With his trunk he ſucks up large quantities of water, carries it to his mouth, drinks part of it, and, by elevating his trunk, makes the remainder run over every part of his body. To give ſome idea of the labour he performs, and the docility of his diſpoſitions, it is worthy of remark, that, in India, all the bales, ſacks, and tuns, tranſported from one place to another, are carried by elephants. They carry burdens on their bodies, their necks, their tuſks, and even in their mouths, by giving them the end of a rope, which they hold faſt with their teeth. Uniting ſagacity with ſtrength, they never break or injure any thing committed to their charge. From the margins of the rivers, they put weighty bundles into boats without wetting them, lay them down gently

* Thevenot, tom. 3, pag. 261. S.

gently and arrange them where they ought to be placed. When the goods are difpofed as their mafters direct, they examine with their trunks whether the articles are properly ftowed; and if a cafk or tun rolls, they go fpontaneoufly in queft of ftones to prop and render it firm.

In the elephant, the fenfe of fmelling is acute, and he is paffionately fond of odoriferous flowers, which he collects one by one, forms them into a nofegay, and, after gratifying his nofe, conveys them to his mouth.

In India, the domeftic elephants, to whom the ufe of water is as neceffary as that of air, are allowed every poffible conveniency for bathing themfelves. The animal goes into a river till the water reaches his belly. He then lies down on one fide, fills his trunk feveral times, and dexteroufly throws the water on fuch parts as happen to be uncovered. The mafter, after cleaning and currying one fide, defires the animal to turn to the other, which command he obeys with the greateft alacrity; and, when both fides have been properly cleaned, he comes out of the river, and ftands fome time on the bank to dry himfelf. The elephant, though his mafs be enormous, is an excellent fwimmer; and, of courfe, he is of great ufe in the paffage of rivers. When employed on occafions of this kind, he is often loaded with two pieces of cannon which admit three or four pound balls, befide great quantities of baggage and feveral men fixed to his ears and tail. When thus heavily loaded, he fpontaneoufly enters the river and fwims over with his trunk elevated in the air for the benefit of refpiration. He is fond of wine and ardent fpirits. By fhowing him a veffel loaded with any of thefe liquors, and promifing him it as the reward of his labours, he is induced to exert the greateft efforts, and to perform the moft painful tafks. The elephant, as we are informed by M. de Buffy, quoted by the Count de Buffon, is employed in dragging artillery over mountains, and, on thefe occafions, his fagacity and docility are confpicuous. Horfes or oxen, when yoked to a cannon, make all their exertions to pull it up a declivity. But the elephant pufhes the breach forward with his front, and, at each effort, fupports the carriage with his knee, which

which he places againſt the wheel. He ſeems to underſtand what his *cornack*, or conductor, ſays to him. When his conductor wants him to perform any painful labour, he explains the nature of the operation, and gives the reaſons which ſhould induce him to obey. If the elephant ſhows a reluctance to the taſk, the cornack promiſes to give him wine, arrack, or any other article that he is fond of, and then the animal exerts his utmoſt efforts. But to break any promiſe made to him is extremely dangerous. Many cornacks have fallen victims to indiſcretions of this kind. 'At Dehan,' ſays M. de Buſſy, 'an elephant, from re-'venge, killed his cornack. The man's wife, who beheld 'the dreadful ſcene, took her two children, and threw 'them at the feet of the enraged animal, ſaying, *Since 'you havè ſlain my huſband, take my life alſo, as well as 'that of my children.* The elephant inſtantly ſtopped, re-'lented, and, as if ſtung with remorſe, took the eldeſt 'boy in its trunk, placed him on its neck, adopted him 'for its cornack, and would never allow any other perſon 'to mount it.'

From the members of the Royal Academy of Sciences, we learn ſome curious facts with regard to the manners of the Verſailles elephant. This elephant, they remark, ſeemed to know when it was mocked, and remembered the affront till it had an opportunity of revenge. A man deceived it, by pretending to throw ſome food into its mouth. The animal gave him ſuch a blow with its trunk as knocked him down, and broke two of his ribs. A painter wanted to draw the animal in an unuſual attitude, with its trunk elevated, and its mouth open. The painter's ſervant, to make it remain in this poſition, threw fruits into its mouth, but generally made only a feint of throwing them. This conduct enraged the elephant; and, as if it knew that the paintèr was the cauſe of this teazing impertinence, inſtead of attacking the ſervant, it eyed the maſter, and ſquirted at him from its trunk ſuch a quantity of water as ſpoiled the paper on which he was drawing. This elephant commonly made leſs uſe of its ſtrength than its addreſs. It looſed, with great eaſe and coolneſs, the buckle of a large double leathern ſtrap,

 with

with which its leg was fixed; and, as the ſervants had wrapped the buckle round with a ſmall cord, and tied many knots upon it, the creature, with much deliberation, looſed the whole, without breaking either ſtrap or the cord.

It is remarked by le P. Vincent Marie, that the elephant, when in a domeſtic ſtate, is highly eſteemed for his gentleneſs, docility, and friendſhip to his governor. When deſtined to the immediate ſervice of princes, he is ſenſible of his good fortune, and maintains a gravity of demeanour correſponding to the dignity of his ſituation. But if, on the contrary, leſs honourable labours are aſſigned to him, he grows melancholy, frets, and evidently diſcovers that he is humbled and depreſſed. He is fond of children, careſſes them, and appears to diſcern the innocence of their manners. The Dutch voyagers relate *, that, by giving elephants what is agreeable to them, they are ſoon rendered perfectly tame and ſubmiſſive. They are ſo ſagacious, that they may be ſaid to be deſtitute of the uſe of language only. They are proud and ambitious; and they are ſo grateful for good uſage, that, as a mark of reſpect, they bow their heads in paſſing houſes where they have been hoſpitably received. They allow themſelves to be led and commanded by a child; but they love to be praiſed and careſſed. When a wild elephant is taken, the hunters tie his feet, and one of them accoſts and ſalutes him, makes apologies for binding him, proteſts that no injury is intended, tells him, that, in his former condition, he frequently wanted food, but that, that, henceforward, he ſhall be well treated, and that every promiſe ſhall be performed to him. This ſoothing harangue is no ſooner finiſhed than the elephant placidly follows the hunter †. From this fact, however, we muſt not conclude that the elephant underſtands language, but that, like the dog, he has a ſtrong diſcerning faculty. He diſtinguiſhes eſteem from contempt, friendſhip from hatred, and many other emotions which are expreſſed by human

* Voyage de la Compagnie des Indes de Hollande, tom. 1. pag. 413. S.

† Voyage d'Orient. du P. Phillippe, pag. 366. S.

human geſtures and features. For this reaſon, the elephant is more eaſily tamed by mildneſs than by blows.

‘ I have frequently remarked,’ ſays Edward Terry *, that ‘ the elephant performs many actions which ſeem to proceed ‘ more from reaſon than from inſtinct. He does every ‘ thing which his maſter commands. If he wants to terrify ‘ any perſon, he runs upon him with every appearance of ‘ fury, and, when he comes near, ſtops ſhort, without doing ‘ the perſon the ſmalleſt injury. When the maſter chooſes to ‘ affront any man, he tells the elephant, who immediately ‘ collects water and mud with his trunk, and ſquirts it ‘ upon the object pointed out to him. The Mogul keeps ‘ ſome elephants who ſerve as executioners to criminals ‘ condemned to death. When the conductor orders one ‘ of theſe animals to deſpatch the poor criminals quickly, ‘ he tears them to pieces in a moment with his feet: But, ‘ if deſired to torment them ſlowly, he breaks their bones ‘ one after another, and makes them ſuffer a puniſhment ‘ as cruel as that of the wheel.’

Next to the elephant, the dog ſeems to be the moſt docile quadruped. A wild dog is a paſſionate, ferocious, and ſanguinary animal. But, after he is reduced to a domeſtic ſtate, theſe hoſtile diſpoſitions are ſuppreſſed, and they are ſucceeded by a warm attachment, and a perpetual deſire of pleaſing. The perceptions and natural talents of the dog are acute. When theſe are aided by inſtruction, the ſagacity he diſcovers, and the actions he is taught to perform, often excite our wonder. Thoſe animals which man has taken under his immediate protection are taught to perform artificial actions, or have their natural inſtincts improved, by three modes of inſtruction, puniſhment, reward, and imitation. More ductile in his nature than moſt other animals, the dog not only receives inſtruction with rapidity, but accommodates his behaviour and deportment to the manners and habits of thoſe who command him. He aſſumes the very tone of the family in which he reſides. Eager, at all times, to pleaſe his maſter, or his friends, he furiouſly repels beggars;

* Terry's Voyage to the Eaſt Indies, pag. 15. S.

beggars; becauſe he probably, from their dreſs, conceives them to be either thieves, or competitors for food.

Though every dog, as well as every man, is naturally a hunter, the dexterity of both is highly improved by experience and inſtruction. The varieties of dogs, by frequent intermixtures with thoſe of different climates, and perhaps with foxes and wolves, are ſo great, and their inſtincts are ſo much diverſified, that, even though they produce with each other, we ſhould be apt to regard them as different ſpecies. What a difference between the natural diſpoſitions of the ſhepherd's dog, the ſpaniel, and the grey-hound? The ſhepherd's dog, independently of all inſtruction, ſeems to be endowed by Nature with an innate attachment to the preſervation of ſheep and cattle. His docility is likewiſe ſo great, that he not only learns to underſtand the language and commands of the ſhepherd, and obeys them with faithfulneſs and alacrity; but, when at diſtances beyond the reach of his maſter's voice, he often ſtops, looks back, and recogniſes the approbation or diſapprobation of the ſhepherd by the mere waving of his hand. He reigns at the head of a flock, and is better heard than the voice of his maſter. His vigilance and activity produce order, diſcipline, and ſafety. Sheep and cattle are peculiarly ſubjected to his management, whom he prudently conducts and protects, and never employs force againſt them, except for the preſervation of peace and good order. But, when the flock committed to his charge is attacked by the fox, the wolf, or other rapacious animals, he makes a full diſplay of his courage and ſagacity. In ſituations of this kind, both his natural and acquired talents are exerted. Three ſhepherds dogs are ſaid to be a match for a bear, and four for a lion.

Every perſon knows the docility and ſagacity of ſuch dogs as are employed in conducting blind mendicants. Johannes Faber, as quoted by Mr. Ray, informs us, that he knew a blind beggar who was led through the ſtreets of Rome by a middle-ſized dog. This dog, beſide leading his maſter in ſuch a manner as to protect him from all danger, learned to diſtinguiſh not only the ſtreets, but the

the houſes where his maſter was accuſtomed to receive alms twice or thrice a-week. Whenever the animal came to any of theſe ſtreets, with which he was well acquainted, he would not leave it till a call had been made at every houſe where his maſter was uſually ſucceſsful in his petitions. When the beggar began to aſk alms, the dog, being wearied, lay down to reſt; but the maſter was no ſooner ſerved or refuſed, than the dog roſe ſpontaneouſly, and, without either order or ſign, proceeded to the other houſes where the beggar generally received ſome gratuity. I obſerved, ſays he, not without pleaſure and ſurpriſe, that, when a halfpenny was thrown from a window, ſuch was the ſagacity and attention of this dog, that he went about in queſt of it, lifted it from the ground with his mouth, and put it into his maſter's hat. Even when bread was thrown down, the animal would not taſte it, unleſs he received a portion of it from the hand of his maſter. Without any other inſtruction than imitation, a maſtiff, when accidentally ſhut out from a houſe which his maſter frequented, uniformly rung the bell for admittance. Dogs can be taught to go to market with money, to repair to a known butcher, and to carry home the meat in ſafety. They can be taught to dance to muſic, and to ſearch for and find any thing that is loſt *.

There is a dog at preſent belonging to a grocer in Edinburgh, who has for ſome time amuſed and aſtoniſhed the people in the neighbourhood. A man who goes through the ſtreets ringing a bell and ſelling penny pies, happened one day to treat this dog with a pie. The next time he heard the pieman's bell, he ran to him with impetuoſity, ſeized him by the coat, and would not ſuffer him to paſs. The pieman, who underſtood what the animal wanted, ſhowed him a penny, and pointed to his maſter, who ſtood in the ſtreet-door, and ſaw what was going on. The dog immediately ſupplicated his maſter by many humble geſtures and looks. The maſter put a penny into the dog's mouth, which he inſtantly delivered to the pieman, and received his pie. This traffick between the pieman

* For theſe and many other inſtances of the ſagacity and docility of the dog, the reader may conſult *Synopſis Quadrupedum a Joanne Raio*, p. 6. *&c.* S.

pieman and the grocer's dog has been daily practiſed for months paſt, and ſtill continues.

Dogs, horſes, and even hogs, by rewards and puniſhments, and, I am afraid, often by cruelty, may be taught to perform actions, as we have frequently ſeen in public exhibitions, which are truly aſtoniſhing. But of theſe we muſt not enter into any detail.

With regard to the horſe, the gentleneſs of his diſpoſitions, and the docility of his temper, are ſo well and ſo univerſally known, that it is unneceſſary to dwell long upon the ſubject. To give ſome idea of what inſtruction horſes receive when in a domeſtic ſtate, we ſhall mention ſome traits of their form and manners when under no reſtraints. In South-America the horſes have multiplied prodigiouſly, and, in that thinly-inhabited country, live in perfect freedom. They fly from the preſence of man. They wander about in troops, and devour, in immenſe meadows, the productions of a perpetual ſpring. Wild horſes are ſtronger, lighter, and more nervous, than the generality of thoſe which are kept in a domeſtic ſtate. They are by no means ferocious. Though ſuperior in ſtrength to moſt animals, they never make an attack.—When aſſaulted, however, they either diſdain the enemy, or ſtrike him dead with their heels. They aſſociate in troops from mutual attachment, and neither make war with other animals nor among themſelves. As their appetites are moderate, and they have few objects to excite envy or diſcord, they live in perpetual peace. Their manners are gentle, and their tempers ſocial. Their force and ardour are rendered conſpicuous only by marks of emulation. They are anxious to be foremoſt in the courſe, to brave danger in croſſing a river, or in leaping a ditch or precipice; and, it is ſaid, that thoſe horſes which are moſt adventurous and expert in theſe natural exerciſes, are, when domeſticated, the moſt generous, mild, and tractable.

Wild horſes are taken notice of by ſeveral of the ancients. Herodotus mentions white wild horſes on the banks of the Hypanis, in Scythia. He likewiſe tells us, that, in the northern part of Thrace, beyond the Danube, there

there were wild horſes covered all over with hair five inches in length. The wild horſes in America are the offspring of domeſtic horſes originally tranſported thither from Europe by the Spaniards. The author of the hiſtory of the Buccaneers* informs us, that troops of horſes, ſometimes conſiſting of 500, are frequently met with in the iſland of St. Domingo; that, when they ſee a man, they all ſtop; and that one of their number approaches to a certain diſtance, blows through his noſtrils, takes flight, and is inſtantly followed by the whole troop. He deſcribes them as having groſs heads and limbs, and long necks and ears. The inhabitants tame them with eaſe, and then train them to labour. In order to take them, gins of ropes are laid in the places where they are known to frequent. When caught by the neck, they ſoon ſtrangle themſelves, unleſs ſome perſon arrive in time to diſentangle them. They are tied to trees by the body and limbs, and are left in that ſituation two days without victuals or drink. This treatment is generally ſufficient to render them more tractable, and they ſoon become as gentle as if they had never been wild. Even when any of theſe horſes, by accident, regain their liberty, they never reſume their ſavage ſtate, but know their maſters, and allow themſelves to be approached and retaken.

From theſe, and ſimilar facts, it may be concluded, that the diſpoſitions of horſes are gentle, and that they are naturally diſpoſed to aſſociate with man. After they are tamed they never forſake the abodes of men. On the contrary, they are anxious to return to the ſtable. The ſweets of habit ſeem to ſupply all they have loſt by ſlavery. When fatigued, the manſion of repoſe is full of comfort. They ſmell it at conſiderable diſtances, can diſtinguiſh it in the midſt of populous cities, and ſeem uniformly to prefer bondage to liberty. By ſome attention and addreſs colts are firſt rendered tractable. When that point is gained, by different modes of management, the docility of the animal is improved, and they ſoon learn to perform with alacrity the various labours aſſigned to them. The domeſtication of the horſe is perhaps the nobleſt

* L'Hiſt. des Avantur. Flibuſtiers. tom. 1. pag. 110. S.

bleſt acquiſition from the animal world which has ever been made by the genius, the art, and the induſtry of man. He is taught to partake of the dangers and fatigues of war, and ſeems to enjoy the glory of victory. He encounters death with ardour and with magnanimity. He delights in the tumult of arms, and attacks the enemy with reſolution and alacrity. It is not in perils and conflicts alone that the horſe co-operates with the diſpoſitions of his maſter. He even ſeems to participate of human pleaſures and amuſements. He delights in the chace and the tournament, and his eyes ſparkle with emulation in the courſe. Though bold and intrepid, however, he does not allow himſelf to be hurried on by a furious ardour. On proper occaſions, he repreſſes his movements, and knows how to check the natural fire of his temper. He not only yields to the hand, but ſeems to conſult the inclination, of his rider. Always obedient to the impreſſions he receives, he flies or ſtops, and regulates his motions ſolely by the will of his maſter.

Mr. Ray, who wrote about the end of laſt century, informs us, that he had ſeen a horſe who danced to muſic, who, at the command of his maſter, affected to be lame, who ſimulated death, lay motionleſs with his limbs extended, and allowed himſelf to be dragged about, till ſome words were pronounced, when he inſtantly ſprung up on his feet *. Facts of this kind would ſcarcely receive credit, if every perſon were not now acquainted with the wonderful docility of the horſes educated by Aſtley, and other public exhibitors of horſemanſhip. In exhibitions of this kind, the docility and prompt obedience of the animals deſerve more admiration than the dexterous feats of the men.

Animals of the ox-kind, in a domeſtic ſtate, are dull and phlegmatic. Their ſenſibility and talents ſeem to be very limited. But we ſhould not pronounce raſhly concerning the genius and powers of animals in a country where their education is totally neglected. In all the ſouthern provinces of Africa and Aſia, there are many wild biſons, or bunched oxen, which are young and tam-

ed.

* Raii Synopſis Animalium Quadrupedum, pag. 10. S.

ed. They are ſoon taught to ſubmit, without reſiſtance, to all kinds of domeſtic labour. They become ſo tractable, that they are managed with as much eaſe as our horſes. The voice of their maſter is alone ſufficient to make them obey, and to direct their courſe. They are ſhod, curried, careſſed, and ſupplied abundantly with the beſt food. When managed in this manner, theſe animals appear to be different creatures from our oxen. The oxen of the Hottentots are favourite domeſtics, companions in amuſements, aſſiſtants in all laborious exerciſes, and participate the habitation, the bed, and the table of their maſters. As their nature is improved by the gentleneſs of their education, by the kind treatment they receive, and the perpetual attention beſtowed on them, they acquire ſenſibility and intelligence, and perform actions which one would not expect from them. The Hottentots train their oxen to war. In all their armies there are conſiderable troops of theſe oxen, which are eaſily governed, and are let looſe by the chief when a proper opportunity occurs. They inſtantly dart with impetuoſity upon the enemy. They ſtrike with their horns, kick, overturn, and trample under their feet every thing that oppoſes their fury. They run ferociouſly into the ranks, which they ſoon put in the utmoſt diſorder, and thus pave the way for an eaſy victory to their maſters*. Theſe oxen are likewiſe inſtructed to guard the flocks, which they conduct with dexterity, and defend them from the attacks of ſtrangers, and of rapacious animals. They are taught to diſtinguiſh friends from enemies, to underſtand ſignals, and to obey the commands of their maſter. When paſturing, at the ſmalleſt ſignal from the keeper, they bring back and collect the wandering animals. They attack all ſtrangers with fury, which renders them a great ſecurity againſt robbers. Theſe *brackeleys*, as they are called, know every inhabitant of the kraal, and diſcover the ſame marks of reſpect for all the men, women, and children, as a dog does for thoſe who live in his maſter's houſe. Theſe people may, therefore, approach their cattle with the greateſt ſafety. But if a ſtranger, and particularly

* Voyage de Cap, par Kolbe, tom. 1. pag. 160. S.

larly an European, ſhould uſe the ſame freedom, without being accompanied with one of the Hottentots, his life would be in imminent danger*.

Notwithſtanding the many ſurpriſing actions which different quadrupeds may be taught to perform, none of them, though their organs are much more perfect than thoſe of birds, have ever been able to pronounce articulate ſounds. But many birds, without much inſtruction, learn to pronounce words, and even ſentences. In parrots, the diſtinguiſhing accuracy of their ear, the acuteneſs of their attention, and their ſtrong inſtinctive propenſity to imitate ſounds of every kind, have juſtly procured them univerſal admiration. When in a ſtate of domeſtication, the parrot learns to pronounce the common ſtreet calls, beſide many words and phraſes occaſionally employed by the family in which he reſides. Tho' the limitation of his mental powers does not permit him to learn any extent of languge, or the proper uſe and meaning of words, he not unfrequently diſcovers the aſſociation between the object and the ſound. A woman every morning paſſed the window, where a parrot's cage was fixed, calling ſalt. The parrot ſoon learned to imitate the call. But, before any ſound could be heard, he no ſooner caſt his eye upon the woman than he uttered her uſual call. In this and many other ſimilar caſes, the objects and the ſounds are evidently connected in the mind of the animals. How far theſe aſſociations might be carried by a patient and perſevering education, it is difficult to determine. In this manner, however, parrots might be taught a conſiderable vocabulary of ſubſtantive nouns, or the proper names of common objects. But his intellect, it is more than probable, would never reach the uſe of the verb, and other parts of ſpeech.

Beſide parrots, jays, &c. who learn to pronounce articulate ſounds, there is another race of birds whoſe docility deſerves to be mentioned. Singing birds, thoſe lively and ſpirited little animals, attempt not to articulate. But their muſical ears are as delicate and diſcerning as their voices are melodious and delightful. The vivacity, the

* Voyage de Cap, par Kolbe, pag. 307. S.

the extent of voice, and the imitative powers of theſe beautiful creatures, have at all times excited the attention and conciliated the affections of mankind. When domeſticated, theſe birds, beſide their natural notes, ſoon acquire the faculty of ſinging conſiderable parts of artificial tunes. Theſe imitations are effects of natural inſtinct. But, in exhibitions, I have ſeen linnets ſimulate death, and remain perfectly tranquil and unmoved, when ſmall cannons were fired, within an inch of their bodies, from a wooden fort. Theſe little creatures have even been taught to lay hold of a match and fire the cannons themſelves.

The docility and ſagacity of animals have always been conſidered as wonderful. But this wonder is partly the effect of inattention; for, though man is unqueſtionably the chief of the animal creation, the other animals, according to the number of inſtincts, or, which amounts to the ſame thing, according to the mental powers with which Nature has endowed them, comparatively approach to or recede from the ſagacity and genius of the human ſpecies. The whole is a graduated ſcale of intelligence. A philoſopher ſhould, therefore, contemplate and admire the whole, but ſhould never be ſurpriſed at any partial exhibitions of the general ſcene of intellect and animation.

We ſhall conclude this ſubject with a few remarks concerning the changes produced in animals by DOMESTICATION.

Climate and food are the chief cauſes which produce changes in the magnitude, figure, colour, and conſtitution, of wild animals. But, beſide theſe cauſes, there are others which have an influence upon animals when reduced to a domeſtic or unnatural ſtate. When at perfect liberty, animals ſeem to have ſelected thoſe particular zones or regions of the globe which are moſt conſonant to the nature and conſtitution of each particular tribe. There they ſpontaneouſly remain, and never, like man, diſperſe themſelves over the whole ſurface of the earth. But, when obliged by man, or by any great revolution of Nature, to abandon their native ſoil, they undergo changes

ges ſo great, that, to recogniſe and diſtinguiſh them, recourſe muſt be had to the moſt accurate examination. If we add to climate and food, thoſe natural cauſes of alteration in free animals, the empire of man over ſuch of them as he has reduced to ſervitude, the degree to which tyranny degrades and disfigures Nature, will appear to be greatly augmented. The mouflon, the ſtock from which our domeſtic ſheep have derived their origin, is comparatively a large animal. He is as fleet as a ſtag, armed with horns and ſtrong hoofs, and covered with coarſe hair. With theſe natural advantages, he dreads neither the inclemency of the ſky, nor the voracity of the wolf. By the ſwiftneſs of his courſe, he not only eſcapes from his enemies, but he is enabled to reſiſt them by the ſtrength of his body and the ſolidity of his arms. How different is this animal from our domeſtic ſheep, who are timid, weak, and unable to defend themſelves? Without the protection of man, the whole race would ſoon be extirpated by rapacious animals and by winter-ſtorms. In the warmeſt climates of Africa and of Aſia, the mouflon, who is the common parent of the ſheep, appears to be leſs degenerated than in any other region. Though reduced to a domeſtic ſtate, he has preſerved his ſtature and his hair: but the ſize of his horns is diminiſhed. The ſheep of Barbary, Egypt, Arabia, Perſia, &c. have undergone greater changes; and, in proportion as they approach toward either pole, they diminiſh in ſize, in ſtrength, in ſwiftneſs, and in courage. In relation to man, they are improved in ſome articles, and vitiated in others. Their coarſe hair is converted into fine wool. But, with regard to Nature, improvement and degeneration amount to the ſame thing; for both imply an alteration of the original conſtitution.

The ox is more influenced by nouriſhment than any other domeſtic animal. In countries where the paſture is luxuriant, the oxen acquire a prodigious ſize. To the oxen of Æthiopia and ſome provinces of Aſia, the ancients gave the appellation of *Bull-Elephants*, becauſe, in theſe regions, they approach to the magnitude of the elephant. This effect is chiefly produced by the abundance

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of rich and ſucculent herbage. The Highlands of Scotland, and indeed every high and northern country, afford ſtriking examples of the influence of food upon the magnitude of cattle. The oxen, as well as the horſes, in the more northern parts of Scotland, are extremely diminutive; but, when tranſported to richer paſture, their ſize is augmented, and the qualities of their fleſh are improved. The climate has likewiſe a conſiderable influence on the nature of the ox. In the northern regions of both continents, he is covered with long ſoft hair. He has likewiſe a large bunch on his ſhoulders; and this deformity is common to the oxen of Aſia, Africa, and America. Thoſe of Europe have no bunch. The European oxen, however, ſeem to be the primitive race, to which the bunched kind aſcend, by intermixture, in the ſecond or third generation. The difference in their ſize is remarkably great. The ſmall zebu, or bunched ox of Arabia, is not one tenth part of the magnitude of the Æthiopian bull-elephant.

The influence of food upon the dog-kind ſeems not to be great. In all his variations and degradations, he appears to follow the differences of climate. In the warmeſt climates, he is naked; in the northern regions, he is covered with a coarſe thick hair; and he is adorned with a fine ſilky robe, in Spain and Syria, where the mild temperature of the air converts the hair of moſt quadrupeds into a kind of ſilk. Beſide theſe external variations produced by climate, the dog undergoes other changes, which proceed from his ſituation, his captivity, and the nature of the intercourſe he holds with man. His ſize is augmented or diminiſhed by obliging the ſmaller kinds to unite together, and by obſerving the ſame conduct with the larger individuals. The ſhortening the tail and ears proceeds alſo from the hand of man. Dogs who have had their ears and tails cut for a few generations, tranſmit theſe defects, in a certain degree, to their deſcendents. Pendulous ears, the moſt certain mark of domeſtic ſervitude and of fear, are almoſt univerſal. Of many races of dogs, a few only have retained the primitive ſtate of

their ears. Erect ears are now confined to the wolf-dog, the ſhepherd's dog, and the dog of the North.

The colour of animals is greatly variegated by domeſtication. The dog, the ox, the ſheep, the goat, the horſe, have aſſumed all kinds of colours, and even mixtures of colours, in the ſame individuals. The hog has changed from black to white; and white, without the intermixture of ſpots, is generally accompanied with eſſential imperfections. Men who are remarkably fair, and whoſe hair is white, have generally a defect in their hearing, and, at the ſame time, weak and red eyes. Quadrupeds which are entirely white have likewiſe red eyes and a dullneſs of hearing. The variations from the original colour are moſt remarkable in our domeſtic fowls. In a brood of chickens, though the eggs be laid by the ſame hen, and though the female be impregnated by the ſame male, not one of them has the ſame colours with another.

Domeſtication not only changes the external appearances of animals, but alters and modifies their natural diſpoſitions. The dog, for example, when in a ſtate of liberty, is a rapacious quadruped, and hunts and devours the weaker ſpecies: But, after he has ſubmitted to the dominion of man, he relinquiſhes his natural ferocity, and is converted into a mean, ſervile, patient, and paraſitical ſlave.

CHAPTER XVIII.

Of the Characters of Animals.

ON this ſubject it never was intended to paint the characters of every ſpecies, even of the larger animals. The reader will eaſily recollect, that, in many parts of this work, much has already been ſaid with regard to the tempers, diſpoſitions, and manners, of a great number of animals. Theſe we ſhall not repeat, but proceed to ſome general remarks.

On every animal Nature has imprinted a certain *character*, which is indelibly fixed, and diſtinguiſhes the ſpecies. This character we diſcover by the actions, the air, the countenance, the movements, and the whole external appearance. The courage of the lion, the ferocity of the tiger, the voraciouſneſs of the wolf, the pride of the courſer, the dulneſs and indolence of the aſs, the cunning and addreſs of the fox, the affection and docility of the dog, the ſubtlety and ſelfiſhneſs of the cat, the mildneſs of the ſheep, the timidity of the hare, the vivacity of the ſquirrel, are proper examples. Theſe characters, when under the influence of domeſtication, may be modified by education, of which rewards and puniſhments are the chief inſtruments employed. But the original character, impreſſed by the hand of Nature, is never fully obliterated. Thoſe animals which ſeem to have been deſtined by Nature to live in perpetual ſlavery under the dominion of man, have the mildeſt and moſt gentle diſpoſitions. It is pleaſant, but, at the ſame time, ſomewhat contemptible, to ſee a troop of oxen guided by the whip of a child.

In the human ſpecies, the variety of tempers, affections, averſions, and ſtudies, is indiſpenſibly neceſſary for ſupporting the ſocial ſtate, and carrying on the general

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bufinefs of life. Some minds are formed for ftudy and deep refearch, and others for action, courage, and the exertion of bodily powers. The fame variety in the difpofitions and manners of the different tribes of animals is equally neceffary for peopling the earth, and for fupplying the reciprocal exigencies of its inhabitants.

Befide the general fpecific characters of animals, individual characters, efpecially among the human race, are ftrongly marked, and greatly variegated. In every government, and particularly in commercial ftates, human characters, independently of the original bias, or genius, ftamped by Nature on individual minds, are often fo difguifed by a thoufand artifices, that it requires not only time, but frequent interefting fcenes, before a man can difcover the real character even of an intimate companion. Many men affociate together in the moft harmonious manner, and fhow every fymptom of friendfhip and attachment; but, when any of them happens to be diftreffed, and to require aid, all this apparent friendfhip inftantly vanifhes; the afpect of the countenance, inftead of exhibiting fympathy and cordiality, is converted into a cold referve, and the unfortunate former companion is firft fhunned, and then deferted. This picture of human nature, we are forry to remark, is too general; but, thank Heaven, it is not univerfal; for there always were, and ftill are, men of noble and generous minds, who willingly facrifice part of their own intereft to that of their friends.

With regard to the characters of quadrupeds, befide the fpecific difpofitions which diftinguifh the different kinds, each individual poffeffes a peculiar character by which it may be difcriminated from any other. Thefe individual characters may be difcovered not only by the afpect, but by the actions, of animals. Some dogs, even of the fame race, are furly, churlifh, and revengeful. Others are gay, frolickfome, and friendly. The countenances of men, which always indicate fome part of their original and genuine character, are as various as their numbers. Though lefs fubject to general obfervation, Nature has marked the countenances of every animal,

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even down to the infect tribes, with fome characteriftic ftrokes, which enable them to diftinguifh one another, and even to contract particular attachments. To us, the fmall birds, fuch as fparrows and linnets, appear to be fo perfectly fimilar, that, though we had an opportunity of feeing great numbers of them collected in one place, it would require much time and attention to be enabled to make particular diftinctions. After they have brought up their young, they affociate promifcuoufly in flocks; but, when the genial fpring arrives, a different fcene is exhibited. The flocks difappear. Each male has felected, courted, and retired with a female to build a neft, to hatch eggs, and to nourifh and fupport their young. If Nature had not ftamped upon every individual a peculiar mark, it would be impoffible that the immenfe multitudes who pair, or join in matrimony, fhould be capable of diftinguifhing and adhering faithfully to one another. A fhepherd, who has been long accuftomed to fuperintend a numerous flock, knows, by the countenances, and other natural or accidental marks, every individual. I knew a fhepherd, who not only diftinguifhed every individual of above two hundred fheep, but gave to each a particular name.

The characters of quadrupeds, and even of fome birds, are indicated by obfcure refemblances between the lineaments of their faces, and thofe of men of different features and difpofitions. Some men, in the general expreffion of their countenances, refemble goats, others fheep, others oxen, others fwine, others lions, others dogs, others foxes, others owls, others hawks. Even in particular races of the fame fpecies, fimilarities of this kind may be traced. I know fome men who refemble terriers, others greyhounds, others fpaniels, others the fhepherd's dog, others the lap-dog, &c. Some of thefe refemblances may be regarded as fanciful, and perhaps they frequently are. But, in general, when the refemblance to a particular animal is ftrongly marked in the human countenance, the difpofitions of the man have a ftriking affinity to thofe of the animal. Men who refemble the fox are uniformly cunning and deceitful.

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Thoſe who reſemble the ox are dull, ſtupid, and phlegmatic. Thoſe who reſemble the lion are bold, open, generous, and witty. Thoſe who reſemble the cat are circumſpect, deſigning, and avaricious. Thoſe who reſemble the greyhound are vigilant, active, and ſmart. Thoſe who reſemble the lap-dog are vain, preſumptuous, petulant, and laſcivious. Thoſe who reſemble the ſow are diſguſtful both in their appearance and in their diſpoſitions. Thoſe who reſemble a croſs-made horſe are cruel, unfeeling, and highly ſelfiſh. Thoſe who reſemble the ſpaniel, of whom the examples are numerous, are fawning, mean, and paraſitical. Thoſe who reſemble the ſheep are dull, timid, and inoffenſive. Thoſe who reſemble the goat are fanciful, obſtinate, and libidinous. Thoſe who reſemble a fine horſe are intrepid, generous, tractable, and good-humoured. Thoſe who reſemble a hawk are quick, deſultory, and ingenious. Thoſe who reſemble the owl are dark, deſigning, and treacherous. Thoſe who reſemble the bee are active, ignorant, and induſtrious. It is needleſs to multiply examples. Every man's recollection and obſervation will furniſh him with numberleſs coincidences between the ſimilarities in ſtructure and features to particular animals, and the form, diſpoſitions, and manners, of the men who poſſeſs them.

Compariſons have been inſtituted, and analogies traced, between the ſtructure, aſpect, and diſpoſitions, of ſome quadrupeds and thoſe of certain birds, which ſhow a uniformity in the general plan of Nature. Among birds, as well as quadrupeds, ſome ſpecies are carnivorous, and others feed upon fruits, grain, and various kinds of herbage. The eagle, which is a noble and a generous bird, repreſents the lion. The vulture, which is cruel and inſatiable, repreſents the tiger. The kite, the buzzard, and the raven, who live chiefly on offals and carrion, repreſent the hyæna, the wolf, and the jackal. The falcon, the ſparrow-hawk, and other birds employed in hunting, repreſent the dog, the fox, the lynx, &c. The owl, who ſearches for her prey in the night, repreſents the cat. The heron and the cormorant, who feed upon fiſhes, repreſent the

the beaver and the otter. Peacocks, hens, and all other birds which have a crop, or craw, repreſent oxen, ſheep, goats, and other ruminating animals.

CHAPTER XIX.

Of the Principle of Imitation.

IMITATION neceſſarily implies ſome degree of intelligence. All animals, particularly thoſe of the more perfect kinds, are endowed with the principle of imitation. The conſequence is obvious, that all animals poſſeſs a certain portion of intellectual power. In man, the principle of imitation appears at a very early period of his exiſtence. In the more advanced ſtages of life, this principle is ſo interwoven with other motives of acting and thinking, that it is difficult to diſtinguiſh it as a ſeparate inſtinct, and equally difficult to conquer the habits and prejudices to which it has given riſe. The leſs a man has cultivated his rational faculties, the more powerful is the principle of imitation over his actions and his habits of thinking. Moſt women, of courſe, are more influenced by the behaviour, the faſhions, and the opinions of thoſe with whom they aſſociate than men. From this almoſt irreſiſtible inſtinct, we ſhould learn the extreme danger of frequenting the company of the diſſolute and unprincipled; for bad habits are ſoon acquired, but very difficult to conquer. It is a comfortable circumſtance, however, that if men, eſpecially when young, are fortunate enough to fall in with the ſociety of the virtuous and intelligent, the principle of imitation, ſo benevolent is Nature, acts with redoubled force. If we attend to our own feelings, we muſt acknowledge, that, in the acquiſition of bad habits, there is an evident force upon our natural inclinations, but that, in virtuous aſſo-

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ciations, the mind acquiesces with pleasure, and feels no restraint in complying with the examples it perceives, nor in acquiring the correspondent habits. We are prone to evil; but, when not corrupted by improper imitations, Nature has made us much more prone to good.

Artificial language, which we learn entirely by imitation, distinguishes us, more than any other circumstance, from the brute creation. The proper use of it likewise forms the chief difference between one man and another; for, by language, one man discovers a superiority of knowledge and of genius, while others express by it nothing but borrowed or confused ideas. In an ideot, or in a parrot, it marks only the most abject degree of stupidity. It shows the incapacity of either to produce a regular chain of thinking, though both of them be endowed with organs capable of expressing what passes within their minds. Men whose senses are delicate, and whose minds are easily affected, make the best actors, and the best mimics. Children, accordingly, are extremely alert in imitating the actions, the gestures, and the manners, of those with whom they associate. They are dexterous in perceiving ridiculous figures and representations, which they imitate with ease and propriety. Hence we perceive, in the education of children, the infinite importance of regulating the principle of imitation.

The education of the inferior animals, though short, is always successful. By imitation, they soon acquire all the knowledge possessed by their parents. They not only derive experience from their own feelings, but, by imitation, they learn and employ the experience of others. Young animals model their actions entirely upon those of the old. They see their seniors approach or fly when they perceive particular objects, hear particular sounds, or smell certain odours. At first, they approach or fly without any other determining principle but that of imitation. Afterwards, they approach or fly spontaneously, because they have then acquired the habit of approaching or flying, whenever they feel the same or similar sensations. Many instincts, as terror upon hearing particular sounds, the appearance of natural enemies, the selection of food, &c. seem

ſeem to be partly the effects of imitation. It is remarked by Ulloa, that, in the year 1743, the dogs in Juan Fernandes had loſt the faculty of barking. When aſſociated with other dogs, it was with great difficulty that they again learned, by imitation, to bark. The cauſe of theſe dogs loſing the expreſſion of their uſual language in a domeſtic ſtate, it is not eaſy to inveſtigate. Perhaps, by the aid of experience, and their own ſagacity, they diſcovered that barking warned their prey to eſcape from danger. The jackals, however, who are conſidered as belonging to the dog-kind, not only hunt in packs, but, during the chace, make a loud and a hideous noiſe. Mr. White, in his Natural Hiſtory of Selborne, a work which contains much information, and diſcovers a good and benevolent heart in the author, informs us, that he had an opportunity of ſeeing two dogs, a male and a female, which had been brought from Canton in China. Theſe dogs, which, in China, are fattened for eating, are about the ſize of an ordinary ſpaniel, and are of a pale yellow colour. ‘ When taken out into a field,’ he remarks, ‘ the ‘ bitch ſhowed ſome diſpoſition for hunting, and dwelt ‘ on the ſcent of a covey of partridges till ſhe ſprung them, ‘ giving her tongue all the time. The dogs in South- ‘ America are dumb ; but theſe bark much in a ſhort thick ‘ manner, like foxes ; and have a ſurly ſavage demeanour, ‘ like their anceſtors, which are not domeſticated, but ‘ bred up in ſties, where they are fed for the table with ‘ rice-meal, and other farinaceous food. Theſe dogs, ‘ having been taken on board as ſoon as weaned, could ‘ not have learned much from their dam ; yet they did ‘ not reliſh fleſh when they came to England. In the ‘ iſlands of the Pacific Ocean, the dogs are bred upon ‘ vegetables, and would not eat fleſh when offered them ‘ by our circumnavigators.’

From facts of this kind, of which a great number might be mentioned, the following obſervations naturally ariſe. Theſe Chineſe dogs, though deſcended, probably for many generations, from a race of anceſtors who never had the leaſt experience or education in hunting, preſerved their original inſtinct of ſcenting and purſuing game.

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The dog is a grofsly carnivorous animal; for he prefers carrion to any other kind of nourifhment; yet the Chinefe dogs difcovered no particular relifh for the flefh of animals. Thus it appears, that, by habits, acquired, not by the individual, but by a train of anceftors, both the tafte and the conftitution of animals may be greatly altered. From the fame facts, however, it is equally evident, that Nature can never be entirely conquered. The moment the Chinefe dogs firft faw a field, they both fcented and hunted game. Imitation and habit feem to have greater effects upon the mode of living, feeding, and the corporeal fabrick, than upon the original inftincts of the mind. Thefe dogs, even when they came to England after a long voyage, had not acquired the habit of greedily devouring, like other dogs, either frefh meat or carrion; but, on the firft opportunity afforded to them, they difcovered an inclination to hunt.

CHAPTER XX.

Of the Migration of Animals.

THE Hon. Daines Barrington, in his *Effay on the Periodical Appearing and Difappearing of certain Birds, at different times of the year* *, has, by many ingenious arguments, as well as curious facts, rendered it extremely probable, that no birds, however ftrong and fwift in their flight, can poffibly fly over fuch large tracts of the ocean as has been commonly fuppofed. He admits partial migrations, or *flittings*, as he calls them, though he does not attempt to afcertain the diftances of thefe flittings. With regard to the fwallows, of which there are feveral fpecies in Britain, fome naturalifts, of whom the Hon. Daines Barrington is one, are inclined to think that they do not leave

* Phil. Tranfact. vol. 62. pag. 265, &c. S.

leave this iſland at the end of autumn, but that they lie in a torpid ſtate till the beginning of ſummer in the banks of rivers, the hollows of decayed trees, the receſſes of old buildings, the holes of ſand-banks, and in ſimilar ſituations. That ſwallows, in the winter months, have ſometimes, though very rarely, been found in a torpid ſtate, is unqueſtionably true. Neither is the inference, that, if any of them can ſurvive the winter in that ſtate, the whole of them may ſubſiſt, during the cold ſeaſon, in the ſame condition, in the ſmalleſt degree unnatural. Still, however, the numbers of ſwallows which appear in this iſland, as well as in all parts of Europe, during the ſummer months, are ſo very conſiderable, that, if the great body of them did not migrate to ſome other climate, they ſhould be much more frequently found in a torpid ſtate. On the contrary, when a few of them are diſcovered in that ſtate, it is regarded as a wonder even by the country people, who have the greateſt opportunities of ſtumbling upon facts of this kind. When, accordingly, a few ſwallows or martins are found torpid, in winter, and have been revived by a gentle heat, the fact, and few ſuch facts there are, is carefully recorded as ſingular in all the periodical publications of Europe.

Mr. Pennant informs us, from undoubted authority, that ſome quails, and other birds which are generally ſuppoſed to leave this iſland in winter, retire to the ſea-coaſts, and pick up their food among the ſea-weeds *.

'Quails,' Mr. Pennant remarks, 'are birds of paſſage; 'ſome entirely quitting our iſland, others ſhifting their 'quarters. A gentleman, to whom this work lies under 'great obligations, has aſſured us, that theſe birds mi'grate out of the neighbouring inland counties, into 'the hundreds of Eſſex in October, and continue there 'all the winter: If froſt or ſnow drive them out of the 'ſtubble fields and marſhes, they retreat to the ſea-ſide, 'ſhelter themſelves among the weeds, and live upon what 'they can pick up from the algæ, &c. between high and 'low water mark. Our friend remarks, that the time 'of

* Brit. Zool. Vol. 1. pag. 210. 2d edit. 8vo. S.

'of their appearance in Eſſex coincides with that of their 'leaving the inland counties *.'

A quail, it muſt be allowed, ſeems to be very much unqualified for a long migration; for its tail is ſhort, the bird never riſes more than twenty or thirty feet from the ground, and it ſeldom flies above three hundred yards at a time. Belon, however, an author of great ſagacity and credit, tells us, that, in his paſſage from Rhodes to Alexandria, many quails, flying from north to ſouth, were taken in his ſhip. From this circumſtance, he remarks, 'I am perſuaded that they ſhift places; for formerly, 'when I ſailed out of the Iſle of Zant to Morea, or Ne-'gropont, in the ſpring, I obſerved quails flying the con-'trary way, at which time, alſo, a great many were taken 'in our ſhip.' This traverſe they might be enabled to accompliſh by paſſing from one iſland to another in the Mediterranean.

Inſtances of ſwallows and ſome other birds alighting on the maſts and cordage of veſſels, at conſiderable diſtances from any ſhore, are not ſo numerous as might be expected. Neither have they been often obſerved flying over ſeas in great flocks. Mr. Peter Collinſon, in a letter printed in the Philoſophical Tranſactions, ſays, 'that Sir 'Charles Wager had frequently informed him, that, in 'one of his voyages home in the ſpring, as he came into 'ſoundings in our channel, a great flock of ſwallows al-'moſt covered his rigging; that they were nearly ſpent 'and famiſhed, and were only feathers and bones; but, 'being recruited by a night's reſt, they took their flight 'in the morning.'

M. Adanſon, in his voyage, informs us, that, about fifty leagues from the coaſt of Senegal, four ſwallows ſettled upon the ſhip, on the ſixth day of October; that theſe birds were taken; and that he knew them to be the true ſwallow of Europe, which he conjectures were then returning to the coaſt of Africa. The Hon. Daines Barrington, with more probability, ſuppoſes that theſe ſwallows, inſtead of being on their paſſage from Europe, were only

* Brit. Zool. Vol. 1. pag. 210. 2d. edit. 8vo. S

only flitting from the Cape de Verde iſlands to the continent of Africa, a much ſhorter flight, but to which they ſeemed to be unequal, as they were obliged, from fatigue, to light upon the ſhip, and fall into the hands of the ſailors.

Swallows, Mr. Kalm remarks, appear in the Jerſies about the beginning of April. They are, on their firſt arrival, wet, becauſe they have juſt emerged from the ſea or lakes, at the bottom of which they had remained in a torpid ſtate during the whole winter. But, Mr. Kalm, who wiſhes to ſupport the torpidity of ſwallows during the winter, likewiſe informs us, that he himſelf met with them at ſea, nine hundred and twenty miles from any land *.

Theſe, and ſimilar facts, the Hon. Daines Barrington endeavours to explain, by ſuppoſing that birds diſcovered in ſuch ſituations, inſtead of attempting to croſs large branches of the ocean, have been forcibly driven from ſome coaſt by ſtorms, and that they would naturally perch upon the firſt veſſel which came within their view.

In Britain, five ſpecies of ſwallows appear in ſummer and diſappear in winter. 1. The houſe-ſwallow makes its appearance about twenty days earlier than the martin, or any other of the ſwallow-tribe. They are often ſeen about the 13th day of April. They diſappear about the end of September. A few days previous to their departure, they aſſemble in great flocks on the tops of houſes, churches, and trees, from whence they are ſuppoſed to take their flight. This unuſual and temporary aſſociation of numbers indicates the impulſe of ſome common inſtinct by which each individual is actuated. The houſe-ſwallow is eaſily diſtinguiſhed from the other ſpecies by the ſuperior forkineſs of its tail, and by a red ſpot on the forehead, and under the chin. This ſpecies builds in chimneys, and makes its neſt of clay, but leaves the top quite open. 2. The martin is inferior in ſize to the former, and its tail is much leſs forked. The martins appear in Britain ſoon after the houſe-ſwallow. They build under the eaves of houſes: The neſt is compoſed of the

* Voy. tom. 1. pag. 24. S.

ſame materials as thoſe of the houſe-ſwallow; but it is covered above, and a ſmall hole only is left in the ſide for the ingreſs and egreſs of the birds. The martins totally diſappear about the beginning of October. 3. The ſand-martin, or bank-martin, is by much the ſmalleſt of the ſwallow-kind that viſit Britain. The ſand-martins arrive very ſoon after the houſe-ſwallow, and diſappear about Michaelmas. They dig conſiderable holes in ſand-pits and in the banks of rivers, where they build their neſts, which conſiſt not of mud, like thoſe of the former ſpecies, but of graſſes and feathers laid together in a very ſlovenly manner. It is worthy of remark, that theſe birds do not employ the cavities they dig in ſummer for winter-quarters; ſince ſand-banks, ſo perforated, have been carefully ſearched in the winter, and nothing was found but empty neſts*. 4. The ſwift, or black martin of Willoughby, is the largeſt of our ſwallows, and is the lateſt of arriving in this country; for the ſwifts are ſeldom ſeen till the beginning of May, and commonly appear, not in flocks, but in pairs. Swifts, like the ſand-martins, carry on the buſineſs of incubation in the dark. They build in the cranies of caſtles, towers, and ſteeples. Straw and feathers are the materials they uſe. They diſappear very early; for they are almoſt never ſeen after the middle of Auguſt. 5. The goatſucker, which belongs to the ſwallow-tribe, is likewiſe a bird of paſſage. Like the other ſwallows, it feeds upon winged inſects. But, inſtead of purſuing its prey during the day, it flies only in the night, and ſeizes moths, and other nocturnal inſects. From this circumſtance, it has not improperly received the appellation of the *nocturnal ſwallow*. The goatſucker ſtays only a ſhort time in Britain. It appears not till about the end of May, and retires in the middle of Auguſt. It lays its eggs, which are commonly two, and ſometimes three, on the bare ground.

To give catalogues of the numerous birds of paſſage which frequent this iſland, as well as other countries, and to mark the times of their arrival and departure, would be deviating entirely from our plan. For circumſtances of

* White's Natural Hiſtory of Selborne, pag. 177. S.

of this kind, the curious may conſult Cateſby, Klein, Linnæi Amœnitates Academicæ, White, &c. But, as the periodical appearance and diſappearance of the ſwallow-tribe have given riſe to different theories and opinions, we ſhall briefly relate thoſe opinions, and conclude with ſome remarks on migration in general.

Herodotus and Proſper Alpinus mention one ſpecies of ſwallow which reſides in Egypt during the whole year *; and Mr. Loten, late governor of Ceylon, aſſured Mr. Pennant, that thoſe of Java never remove. If theſe be excepted, all the other known kinds retreat or migrate periodically. Swallows migrate from almoſt every climate. They remove from Norway †, from North-America ‡, from Kamtſchatka §, from the temperate parts of Europe, from Aleppo ‖, and from Jamaica ¶.

Concerning the periodical appearance and diſappearance of ſwallows, there are three opinions adopted by different naturaliſts. The firſt and moſt probable is, that they remove from climate to climate at thoſe particular ſeaſons when winged inſects, their natural food, fails in one country or diſtrict and abounds in another, where they likewiſe find a temperature of air better ſuited to their conſtitutions. In ſupport of this opinion, we have the teſtimony, as formerly mentioned, of Sir Charles Wager, of M. Adanſon, and of many navigators. It is equally true, however, that ſome ſpecies of ſwallows have been occaſionally found in a torpid ſtate during winter. Mr. Collinſon gives the evidence of three gentlemen who were eye-witneſſes to a number of ſand-martins being drawn out of a cliff on the Rhine in the month of March 1762 **. The Hon. Daines Barrington, in the year 1768, communicated to Mr. Pennant, on the authority of the late Lord Belhaven, the following fact: 'That numbers 'of ſwallows have been found in old dry walls, and in ſand-'hills, near his Lordſhip's ſeat in Eaſt-Lothian; not once 'only,

* Profſp. Alp. tom. 1. pag. 198. S.
† Pontopp. Hiſt. Norw. ii. 98. S.
‡ Cateſby's Carol. v. 1. pag. 51. App. 8. S.
§ Hiſt. Kamtſchatka, pag. 162. S.
‖ Ruſſel's Alep. pag. 70. S.
¶ Phil. Tranſ. No. 36. S.
** Philoſoph. Tranſact. vol. 53, pag. 101. art. 24. S.

'only, but from year to year; and that, when they were 'exposed to the warmth of a fire, they revived *.' These, and other facts of the same kind, seem to be uncontrovertible; and Mr. Pennant infers from them, that 'we must 'divide our belief relating to these two so different opini-'ons, and conclude, that one part of the swallow tribe 'migrate, and that others have their winter-quarters near 'home †.' But we should rather incline to think, with those naturalists who suppose that that the torpid swallows which are occasionally, though very rarely, discovered in the winter season, have been obliged to remain behind, because they were too young, weak, diseased, or superannuated, to undertake a long and fatiguing flight. Still, however, that the torpidity of the feathered tribes should be solely confined to the swallows, is a very singular fact in the history of nature. Among quadrupeds, there are many species who lie in a dormant or torpid state during winter. But, if the swallow be excepted, not a single species of birds, notwithstanding the great numbers which, at stated times, appear and disappear in every corner of the globe, has ever been discovered in that state. This circumstance alone, though we cannot yet ascertain the precise places to which different species of birds of passage resort, is a most convincing proof of migration in general.

It has been asserted, and even believed, by some naturalists, that swallows pass the winter immersed under the ice, at the bottom of lakes, or beneath the waters of the sea. Olaus Magnus, Archbishop of Upsal, seems to have been the first who adopted this opinion. He informs us, that swallows are found in great clusters at the bottoms of the northern lakes, with mouth to mouth, wing to wing, foot to foot, and that in autumn they creep down the reeds to their subterraneous retreats ‖. 'That the good 'Archbishop,' Mr. Pennant archly remarks, 'did not 'want credulity in other instances, appears from this, that, 'after having stocked the bottoms of the lakes with birds, 'he

* Pennant's British Zoology, vol. 2. pag. 250. 8vo. edit. S.
† Ibid 251. S.
‖ Derham's Phys.-Theol. pag. 349. S.

'he ftores the clouds with mice, which fometimes fall in 'plentiful fhowers on Norway and the neighbouring coun- 'tries!' Klein has endeavoured to fupport the notion that fwollows lie under water during the winter, and gives the following account of their manner of retiring, which he collected from fome countrymen: They afferted, he tells us, that the fwallows fometimes affembled in numbers on a reed till it broke and funk them to the bottom: That their immerfion was preceeded by a kind of dirge, which lafted more than a quarter of an hour: That others united, laid hold of a ftraw with their bills, and plunged down in fociety: That others, by clinging together with their feet, formed a large mafs, and in this manner committed themfelves to the deep†.

Two reafons feem to render this fuppofed fubmerfion of fwallows impoffible. In the firft place, no land-animal can exift fo long without fome degree of refpiration. The otter, the feal, and water fowls of all kinds, when confined under the ice, or entangled in nets, foon perifh; yet it is well known, that animals of this kind can remain much longer under water than thofe who are deftitute of that peculiar ftructure of the heart which is neceffary for any confiderable refidence beneath that penetrating element. Mr. John Hunter, in a letter to Mr. Pennant, informs us, 'That he had diffected many fwal- 'lows, but found nothing in them different from other 'birds as to the organs of refpiration: That all thofe 'animals which he had diffected of the clafs that fleep 'during winter, fuch as lizards, frogs, &c. had a very 'different conformation as to thofe organs: That all thofe 'animals, he believes, do breathe in their torpid ftate; 'and, as far as his experience reaches, he knows they 'do; and that, therefore, he efteems it a very wild opi- 'nion, that terreftrial animals can remain any long time 'under water without drowning.' Another argument againft their fubmerfion arifes from the fpecific gravity of the animals themfelves. Of all birds, the fwallow tribes are perhaps the lighteft. Their plumage, and the comparative fmallnefs of their weight, indicate that Nature

† Klein Prod. Hift. Avium, pag. 205—206. S.

ture deſtined them to be almoſt perpetually on the wing in queſt of food. From this ſpecific lightneſs, the ſubmerſion of ſwallows, and their continuing for months under water, amount to a phyſical impoſſibility. Even water-fowls, when they wiſh to dive, are obliged to riſe and plunge with conſiderable exertion, in order to overcome the reſiſtance of the water. Klein's idea of ſwallows employing reeds and ſtraws as means of ſubmerſion is rather ludicrous; for theſe light ſubſtances, inſtead of being proper inſtruments for aſſiſting them to reach the bottom, would infallibly contribute to ſupport them on the ſurface, and prevent the very object of their intention. Beſides, admitting the poſſibility of their reaching the bottom of lakes and ſeas, and ſuppoſing they could exiſt for ſeveral months without reſpiration, What would be the conſequence? The whole would ſoon be devoured by otters, ſeals, and fiſhes of various kinds. Nature is always anxious for the preſervation of ſpecies. But, if the ſwallow tribes were deſtined to remain torpid, during the winter months, at the bottom of lakes and ſeas, ſhe would act in oppoſition to her own intentions; for, in a ſeaſon or two, the whole genus would be annihilated.

Mr. White of Selborne has favoured us with the following information concerning the migration of ſwallows: 'If ever I ſaw,' ſays he, 'any thing like actual 'migration, it was laſt Michaelmas day, 1768. I was 'travelling, and out early in the morning: At firſt there 'was a vaſt fog; but, by the time that I was got ſeven 'or eight miles from home towards the coaſt, the ſun 'broke out into a delicate warm day. We were then on 'a large heath or common, and I could diſcern, as the 'miſt began to break away, great numbers of ſwallows 'cluſtering on the ſtinted ſhrubs and buſhes, as if they 'had rooſted there all night. As ſoon as the air became 'clear and pleaſant, they all were on the wing at once, and, 'by a placid and eaſy flight, proceeded on ſouthward to'wards the ſea: After this I did not ſee any more flocks, 'only now and then a ſtraggler. When I uſed to riſe in 'a morning laſt autumn, and ſee the ſwallows and mar'tins cluſtering on the chimneys and thatch of the neigh-

'bouring

'bouring cottages, I could not help being touched with 'secret delight, mixed with some degree of mortification: 'With delight, to observe with how much ardour and 'punctuality those poor little birds obeyed the strong im-'pulse towards migration, or hiding, imprinted on their 'minds by their great Creator; and with some degree of 'mortification, when I reflected, that, after all our pains 'and enquiries, we are yet not quite certain to what 'regions they do migrate; and are still farther embar-'rassed to find, that some do not actually migrate at all*.'

In another part of his work, Mr. White says: 'But 'we must not deny migration in general; because migra-'tion certainly does subsist in some places, as my brother 'in *Andalusia* has fully informed me. Of the motions of 'these birds he has ocular demonstration, for many weeks 'together, both spring and fall: During which periods, 'myriads of the swallow-kind traverse the Straits from 'north to south, and from south to north, according to 'the season. And these vast migrations consist not only 'of *hirudines* (swallows), but of *bee-birds*, *hoopoes*, *oro-'pendulos*, or *golden-thrushes*, &c. &c. and also many of 'our *soft-billed summer birds of passage*; and, moreover, 'of birds which never leave us, such as all the various 'sorts of hawks and kites. Old Belon, two hundred years 'ago, gives a curious account of the incredible armies of 'hawks and kites, which he saw in the spring-time tra-'versing the Thracian Bosphorus from Asia to Europe. 'Besides the above mentioned, he remarks, that the pro-'cession is swelled by whole troops of eagles and vul-'tures †.'

Mr. White, likewise, with much propriety, remarks, that our inquiries concerning the migration of birds have been too much confined to the swallow tribes, while little attention has been paid to the short-winged birds of passage, such as quails, red-starts, nightingales, white-throats, black-caps, &c. All these, though seemingly ill qualified for long flights, disappear in the winter, and not one of them,

* White's Natural History of Selborne, pag. 64.—65. S.
† Ibid. pag. 139. S.

them, notwithſtanding their immenſe numbers, has ever been found in a torpid ſtate.

To mark the times of the arrival and departure of birds of paſſage in different countries, and in different diſtricts of the ſame countries, and the probable motives ariſing from the ſtate of the country with regard to heat and cold, and to that of the food peculiar to each kind, would throw much light upon the hiſtory of migration. To Mr. White of Selborne we are obliged for the following liſts of birds of paſſage which he has obſerved in his neighbourhood. Theſe liſts are arranged nearly in the order of time.

Liſt of Summer Birds of Paſſage.

Names.	*Uſually appear about*
1. Wryneck,	Middle of March.
2. Smalleſt willow-wren,	March 23.
3. Houſe-ſwallow,	April 13.
4. Martin,	Ibid.
5. Sand-martin,	Ibid.
6. Black-cap,	Ibid.
7. Nightingale,	Beginning of April.
8. Cuckoo,	Middle of April.
9. Middle willow-wren,	Ibid.
10. White-throat,	Ibid.
11. Red-ſtart,	Ibid.
12. Stone-curlew,	End of March.
13. Turtle-dove,	———
14. Graſshopper lark,	Middle of April.
15. Swift.	April 27.
16. Leſs reed-ſparrow,	———
17. Land-rail,	———
18. Largeſt willow-wren,	End of April.
19. Goat-ſucker, or fern-owl,	Beginning of May.
20. Fly-catcher,	May 12. This is the lateſt ſummer bird of paſſage.

Moſt ſoft-billed birds feed upon inſects, and not on grain or ſeeds; and, therefore, they retire before winter. But

But the following ſoft-billed birds, though they eat inſects, remain with us during the whole year; ſuch as the red-breaſt and wren, who frequent out-houſes and gardens during the winter, and eat ſpiders, &c.; the hedge-ſparrow, who frequents ſinks for crumbs and other ſweepings; the white wagtail, the yellow wagtail, and the grey wagtail, who frequent ſhallow rivulets near the ſpring heads, where the water ſeldom freezes, and feed upon the aureliæ of inſects; the wheat-ear, ſome of which are to be ſeen during the winter, &c.

Liſt of Winter Birds of Paſſage in the neighbourhood of Selborne.

1. The ring-ouſel *. This bird appears about Michaelmas week, and is a new migration lately diſcovered by Mr. White.

2. The red-wing †, or wind-thruſh, appears in Britain about old Michaelmas. They come in great flocks from the frozen regions of the north.

3. Field-fare ‖. Theſe birds viſit Britain in immenſe numbers about Michaelmas, and depart about the end of February, or the beginning of March. They paſs the ſummer in the northern parts of Europe, and likewiſe in Lower Auſtria §. They breed in the largeſt trees, feed on berries of all kinds ¶, but prefer thoſe of the juniper. It is probable that the field-fares which migrate into Britain come from Norway and the northern regions of Europe, becauſe we find that they both breed and winter in Pruſſia, Auſtria **, and the more temperate climates.

4. The Royſton-crow ††, or hooded-crow of our countryman Sir Robert Sibbald, is likewiſe a bird of paſſage. It viſits us in the beginning of winter, and departs with the wood-cocks. They frequent the inland as well as the maritime parts of Britain. When near the coaſts, they feed upon crabs, muſcles, and other ſhell-fiſhes. They breed in Sweden, build their neſts in trees, and lay four

 eggs.

* Turdus *torquatus.*
† Turdus *iliacus.*
‖ Turdus *pilaris.*
§ Kramer Elench. pag. 361. S.
¶ Linn. Faun. Suec. ſp. 78. S.
** Klein Hiſt. Avium. pag. 178. S.
†† Corvus *Cornix.*

eggs *. They likewiſe breed in the ſouthern parts of Germany, and particularly on the banks of the Danube †.

5. The wood-cock ‖ appears in this country about old Michaelmas. During the ſummer, wood-cocks inhabit the Alps §, Norway, Sweden ¶, and the northern parts of Europe. From theſe countries they retire as ſoon as the froſt commences, which obliges them to migrate into milder climates, where the ſoil is open, and more adapted to their mode of feeding; for they live on worms, which they ſearch for with their long bills in ſoft and moiſt grounds in the midſt of woods. Wood-cocks, taking the advantage of the night, or of foggy weather, arrive here in flocks: But they ſoon ſeparate; and, before returning to their ſummer quarters, they pair. They fly and feed during the night. They begin their flight in the evening, and return to their retreats in the glades when day commences. They depart from Britain about the end of February or the beginning of March. Some of them, however, like the ſtraggling ſwallows, have been known to breed, and to remain here, during the whole year **. It is likewiſe known that wood-cocks migrate from France, Germany, and Italy, and that they make choice of cold northern climates for their ſummer reſidence. About the end of October they viſit Burgundy, but remain there four or five weeks only; becauſe it is a dry country, and, on the firſt froſts, they are obliged to retire for want of ſuſtenance. In the winter they are found as far ſouth as Smyrna, Aleppo ††, and Barbary ‡‡. They are even very common in Japan §§.

6. The ſnipe ‖‖. Snipes are enrolled as birds of paſſage by Mr. White, though he acknowledges that ſome of them conſtantly breed in England. ‘In winter,’ Mr. Pennant remarks, ‘ſnipes are very frequent in all our marſhy ‘and wet grounds, where they lie concealed in the ruſhes, ‘&c.

* Linn. Faun. Suec. ſp. 88. S.

† Kramer, pag. 333. S.

‖ Scolopax *Ruſticola*.

§ Willoughby's Ornithology, pag. 290. S.

¶ M. de Geer's and Dr. Wallerius's letters to Mr. Pennant. S.

** Pennant's Britiſh Zoology, vol. 2. pag. 349. 8vo. S.

†† Ruſſel's Hiſtory of Aleppo, pag. 64. S.

‡‡ Shaw's Travel's, pag. 253. S.

§§ Kæmpfer's Hiſt. Japan. vol. 1. pag. 129. S.

‖‖ Scolopax *Gallinago*.

'&c. In the ſummer they diſperſe to different parts, and 'are found in the midſt of our higheſt mountains as well 'as our low moors. Their neſt is made of dried graſs. 'They lay four eggs of a dirty olive colour, marked with 'duſky ſpots. Their young are ſo often found in Eng-'land, that we doubt whether they ever entirely leave 'this iſland *.'

7. The jack-ſnipe. This bird, which is very common in Scotland, and frequents the banks of rivers and lakes, is ranked by Mr. White as a winter bird of paſſage, without mentioning either the time of its arrival or departure; and Mr. Pennant is entirely ſilent on the ſubject †.

8. The wood-pigeon. Mr. White, without mentioning either the time of their appearing or diſappearing, tells us, that 'they ſeldom appear till late; nor in ſuch 'plenty as formerly ‡.'

9. The wild ſwan ||. During hard winters, this bird frequents the coaſts of Britain in large flocks; but from any information we have been able to obtain, it does not breed in our iſland. Martin in his Hiſtory of the Hebrides, or Weſtern iſles §, informs us, that wild ſwans arrive in great numbers in Lingey, one of the Hebrides, in the month of October, and remain there till March, when they retire more northward to breed. For this purpoſe, the ſwans, like moſt other water-fowls, prefer ſuch places as are leaſt frequented by mankind. During ſummer, the lakes, marſhes, and foreſts of Lapland are filled with myriads of water-fowls. In that northern region, ſwans, geeſe, the duck-tribe, gooſanders, divers, &c. paſs the ſummer; but in autumn they return to us, and to other more hoſpitable ſhores ¶.

10. The wild gooſe. The wild geeſe, it is probable, breed in the retired regions of the north. They arrive here, in the beginning of winter, and frequently feed on our

* Pennant's Britiſh Zoology, vol. 2. pag. 358. 8vo. S.

† White's Natural Hiſtory of Selborne, pag. 117. and Pennant's Britiſh Zoology, vol. 2. pag. 359. 8vo. S.

‡ White's Natural Hiſtory of Selborne, pag. 117. S.

|| Anas *Cygnus ferus*.

§ Deſcription of the Weſtern Iſles, pag. 71. S.

¶ Linn. Flora Lapponica, pag. 273. Oeuvres de Maupertuis, tom. 3. pag. 141. S.

our corn grounds. They fly at a great heighth, and obſerve regularity in their movements. They ſometimes form a ſtraight line; and, at others, they aſſume the ſhape of a wedge, which facilitates their progreſs through the reſiſting air.

With regard to the wild-duck, pochard, wigeon, and teal, though Mr. White places them in the liſt of birds of paſſage, he does not mention either the times of their arrival or departure. Though it be probable that moſt of the duck-kind migrate, yet it is certain, that ſome individuals of different ſpecies of them breed in this country, and continue in it during the whole year. As to the duck-kind in general, Mr. Pennant remarks: 'Of 'the numerous ſpecies that form this genus, we know 'of no more than five that breed here. The *tame ſwan* 'and *tame gooſe*, the *Shield duck*, the *eider duck*, and a 'very ſmall portion of the *wild ducks*. The reſt contri-'bute to form that amazing multitude of water-fowl that 'annually repair from moſt parts of Europe to the woods 'and lakes of Lapland, and other Arctic regions *, there 'to perform the functions of incubation and nutrition in 'full ſecurity. They and their young quit their retreat 'in September, and diſperſe themſelves over Europe. 'With us they make their appearance the beginning of 'October, circulate firſt round our ſhores, and, when 'compelled by ſevere froſt, betake themſelves to our 'lakes and rivers †.'

In winter, the bernacles, or brent-ducks, appear in vaſt flocks on the north-weſt coaſts of Britain. They are very ſhy and wild; but, when taken, they ſoon grow as familiar as our domeſtic ducks. They leave the Britiſh ſhores in February, and migrate as far as Lapland, Greenland, and even Spitſbergen ‡.

The ſolan-geeſe, or gannets, are likewiſe birds of paſſage. They frequent the iſle of Ailſay, near the Frith of Clyde; the rocks adjacent to St. Kilda, the moſt remote of the Hebrides; the Skelig iſles, off the coaſt of Kerry; and

* Collect. Voyag. Dutch Eaſt India Company, 8vo, 1703. pag. 19. Cluſii Exot. pag. 368. S.

† Pennant's Britiſh Zoology, vol. 2. pag. 519—520. S.

‡ Linn. Amoen. Acad. tom. 4. pag. 585. Barent's Voyage, pag. 19. S

and the Bafs-ifle in the Frith of Forth. The multitudes which frequent thefe places are prodigious. To give an idea of their numbers, the reader will not be difpleafed to fee Dr. Harvey's fhort account of the Bafs. 'There is a 'fmall ifland in the Frith of Forth, called the *Bafs-Ifland*, 'which does not exceed a mile in circumference. The 'furface of this ifland, during the months of May and 'June, is fo entirely covered with nefts, eggs, and young 'birds, that it is fcarcely poffible to walk without treading 'on them. The flocks of birds on the wing are fo prodi-'gious, that they darken the air like clouds, and their 'noife is fo great, that a man cannot without difficulty 'hear his neighbour's voice. If, from the top of the 'precipice, you look down upon the fea, you will fee it 'on every fide covered with infinite numbers of birds of 'different kinds, fwimming about and hunting for their 'prey. When failing round the ifland, if you furvey the 'hanging cliffs, you will perceive, in every cragg, or fif-'fure of the rocks, innumerable birds of various kinds, 'more than the ftars of heaven in a ferene night. If you 'view the diftant flocks, either flying to or from the ifland, 'you will imagine them to be a vaft fwarm of bees *.' The rocks of St. Kilda feem to be equally frequented by folan geefe; for Martin, in his defcription of the Hebrides, informs us, that the inhabitants of this fmall ifland confume annually no lefs than 22,600 young birds of this fpecies, befide an amazing number of their eggs. The folan geefe and their eggs conftitute the chief food of thefe iflanders. They preferve both the fowls and the eggs in fmall pyramidal ftone buildings, which, to protect the food from moifture, they cover with the afhes of turf. The folan geefe are birds of paffage. Their firft appearance is in March, and they continue till Auguft or September. But, in general, the times of their breeding and departure feem to coincide with the arrival of the herring, and the migration of that fifh from our coafts. It is more than probable that thefe birds attend the herrings and pilchards during their whole circuit round the Britifh iflands; for the appearance of the folan geefe is always

* Harvey de Generat. Animal. Exercit. 11. S.

always eſteemed by the fiſhermen as a certain preſage of the approach of the herrings or pilchards. In queſt of food, theſe birds migrate as far ſouth as the mouth of the Tagus; for they are frequently ſeen off Liſbon during the month of December.

The croſs-beak, the croſs-bill, and the ſilk-tail, are likewiſe enumerated by Mr. White as birds of paſſage. 'But 'theſe,' ſays he, 'are only wanderers that appear occa- 'ſionally, and are not obſervant of any regular mi- 'gration *.'

The long-legged plover, and ſanderling, viſit us in winter only; and it is worthy of remark, that every ſpecies of the curlews, wood-cocks, ſand-pipers, and plovers †, which forſake us in the ſpring, retire to Sweden, Poland, Pruſſia, Norway, and Lapland, both to feed and to breed. They return to us as ſoon as the young are able to fly; becauſe the froſts, which ſet in early in theſe countries, totally deprive them of the means of ſubſiſtence. For the ſame reaſon they leave us in ſummer, as the dryneſs and hardneſs of the ground prevent them from penetrating the earth with their bills in queſt of worms, which conſtitute the natural food of theſe birds.

From the facts which have been enumerated, and from others of a ſimilar nature, it is evident, that many birds, both of the land and water kinds, migrate from one climate to another. But, even in the ſame climate and country, birds occaſionally perform partial migrations. During hard winters, when the ſurface of the earth is covered with ſnow, many birds, as larks, ſnipes, &c. retire from the inland parts of the country to the ſea-ſhores, where they pick up a ſcanty ſubſiſtence. Others, as the wren, the red-breaſt, and many of the ſmall birds, or ſparrow-kind, reſort to gardens, and the habitations of men. Their intention, it is obvious, is to procure food and ſhelter.

There are three principal objects of migration: Food, temperature of air, and convenient ſituations for breeding. Such birds as migrate to great diſtances are alone denominated

* White's Natural Hiſtory of Selborne, pag. 118. S.

† Linn. Amoen. Acad. tom. 4. pag. 588. Klein de Avium Migrat. pag. 187. S.

minated *birds of paſſage.* But all birds are, in ſome meaſure, birds of paſſage, though they do not migrate to places ſo remote from their former abodes. At particular times of the year, moſt birds migrate from one country to another, or from the more inland diſtricts toward the ſhores. Theſe partial migrations of ſmall birds are well known to bird-catchers, who make a livelihood by enſnaring them into their nets, and ſelling them. The birds *fly*, as the bird-catchers term it, about the end of September, and during the months of October and November. There is another, but leſs conſiderable, flight in March. Some begin their flight annually about Michaelmas; others, as the wood-larks, ſucceed, and continue their flight till the middle of October; but the greenfinch does not migrate till the froſt obliges it to remove in queſt of food and ſhelter. Theſe partial migrations, or flittings, are performed from day-break till noon. Another, but ſmaller, flight commences at two o'clock, and continues till night approaches. The times when particular birds migrate from one ſituation to another are well known to the bird-catchers, who, by means of call-birds, nets, and other devices, ſeize great numbers of them, and, after accuſtoming them for ſome time to reſtraint and ſlavery, ſell them, for conſiderable prices, to curious men and whimſical women. A diligent attention to theſe partial migrations, and their motives, would ſoon unfold the cauſes of thoſe of a more extenſive kind.

Migration is generally ſuppoſed to be peculiar to the feathered tribes. This is a limited idea, which has originated from inattention to the œconomy of nature. Birds migrate with a view to remedy the inconveniencies of their preſent ſituation, and to acquire a more commodious ſtation with regard to food, temperature, generation, and ſhelter. From ſimilar motives, men, ſometimes in amazing multitudes, have migrated from north to ſouth, diſplaced the native inhabitants, and fixed eſtabliſhments in more comfortable climates than thoſe which they had relinquiſhed. Theſe, in their turn, have fallen victims to freſh and barbarous emigrants. Among the inhabitants of the more northern nations, as Norway, Sweden,

den, Scotland, &c. notwithſtanding a very ſtrong attachment to their native countries, there ſeems to be a natural or inſtinctive propenſity to migrate. Poverty, the rigour of climate, curioſity, ambition, the falſe repreſentations of intereſted individuals, the oppreſſion of feudal barons, and ſimilar circumſtances, have of late given riſe to great emigrations of the human ſpecies. But, it is worthy of remark, that the emigrations from ſouth to north, except from the love of conqueſt in ambitious nations, are ſo rare, that the inſtinct ſeems hardly to exiſt in thoſe more fortunate climates. Curioſity is a general inſtinctive principle, which operates ſtrongly in the youthful periods of life, and ſtimulates every man to viſit places that are diſtant from his ordinary reſidence. This innate deſire is influenced by the relations of travellers, and by many other incentives of a more intereſted kind. Without the principle of migration, mankind, it is probable, would never have been ſo univerſally diffuſed over the ſurface of the earth. It is counterbalanced, however, by attachment to thoſe countries which gave us birth, a principle ſtill more powerful and efficient. Love of our native country is ſo ſtrong, that, after gratifying the migrating principle, almoſt every man feels a longing deſire to return.

Savages, as long as their ſtore of food remains unexhauſted, continue in a liſtleſs inactive ſtate. They exhauſt many days ſitting in perfect indolence, and ſeem not to be prompted by any motives of curioſity. They have not a conception of a man's walking either for amuſement or exerciſe. But, when their proviſions begin to fail, an aſtoniſhing reverſe takes place. They then rouſe as from a profound ſleep. In queſt of wild beaſts, birds, and fiſhes, they migrate to immenſe diſtances, exert the greateſt feats of activity, and undergo incredible hardſhips and fatigue. After acquiring a ſtore of proviſions, they return to their wonted haunts, and remain inactive till their food again begins to fail.

Quadrupeds likewiſe perform partial migrations. At the approach of winter, the ſtag, the rein-deer, and the roebuck, leave the tops of the lofty mountains, and come down to the plains and copſes. Their chief objects, in

theſe

these flittings, are food and shelter. When summer commences, they are harrassed with different species of winged insects, and, to avoid these enemies, they regain the summits of the mountains, where the cold and the heighth of the situation protect them from the attacks of the flies. In Norway, and the more northern regions of Europe, the oxen, during the winter, migrate to the shores of the sea, where they feed upon sea-plants and the bones of fishes; and Pontoppidan remarks, that the cattle know by instinct when the tide retires, and leave these articles of food upon the shore. In Orkney and Shetland, the sheep, in winter, for the same purposes, uniformly repair to the shore at the ebbing of the tides. Rats, particularly those of the northern regions of Europe, appear, from time to time, in such myriads, that the inhabitants of Norway and Lapland imagine the animals fall from heaven. The celebrated Linnæus, who paid great attention to the œconomy of these migrating rats, remarked, that they appeared in Sweden periodically every eighteen or twenty years. When about to migrate, they leave their wonted abodes, and assemble together in numbers inconceivable. In the course of their journey, they make tracks in the earth of two inches in depth; and these tracks sometimes occupy a breadth of several fathoms. What is singular, the rats, in their march, uniformly pursue a straight line, unless they are forced to turn aside by some unsurmountable obstacle. If they meet with a rock, they first try to pierce it, and, after discovering the attempt to be impracticable, they go round it, and then resume the straight line. Even a lake does not interrupt their passage; for they either traverse it in a straight line or perish in the attempt; and, if they meet with a bark or other vessel, they do not alter their direction, but climb up the one side of it and descend by the other.

Frogs, immediately after their transformation from the tadpole state, leave the water, and migrate to the meadow or marshy grounds in quest of insects. The numbers of young frogs, which suddenly make their appearance in the plains, induced Rondeletius, and many other naturalists, to imagine that they were generated in the

 clouds

clouds and ſhowered down upon the earth. But if, like the worthy and intelligent Dr. Derham, they had examined the ſituation of the place with regard to ſtagnating waters, and attended to the nature and transformation of the animals, they would ſoon have diſcovered the real cauſe of the phenomenon.

Of all migrating animals, particular kinds of fiſhes make the longeſt journies, and in the greateſt numbers. The multiplication of the ſpecies, and the procuring of food, are the principal motives of the migration of fiſhes. The ſalmon, a fiſh which makes regular migrations, frequents the northern regions alone. It is unknown in the Mediterranean ſea, and in the rivers which fall into it both from Europe and Africa. It is found in ſome of the rivers of France that empty themſelves into the ocean *. Salmons are taken in the rivers of Kamtſchatka †, and appear as far north as Greenland. Salmons live both in the ocean and in freſh waters. For the purpoſe of depoſiting their ſpawn, they quit the ſea in the month of September, and aſcend the rivers. So ſtrong is the inſtinct of migrating, that they preſs up the rivers with amazing keenneſs, and ſcarcely any obſtacle is ſufficient to interrupt their progreſs. They ſpring, with great agility, over cataracts of ſeveral feet in heighth. In their leaps, they ſpring ſtraight up with a ſtrong tremulous motion, and do not, as has been vulgarly ſuppoſed, put their tails in their mouths. When they find a place which they think proper for depoſiting their eggs, the male and female unite their labours in forming a convenient receptacle for the ſpawn in the ſand, which is generally about eighteen inches deep. In this hole the female depoſits her eggs, and the male his milt, which they are ſaid to cover carefully with their tails; for, after ſpawning, their tails are deprived of ſkin. The eggs, when not diſturbed by violent floods, lie buried in the ſand till the ſpring, and they are hatched about the end of March. The parents, however, after this important office has been performed, haſten back to the ſea, in order to cleanſe themſelves, and to recover their ſtrength. Toward the end of March, the

* Rondelet. de Fluviat. pag. 167. S. † Hiſt. Kamtſchatka, pag. 143. S.

the young fry begin to appear, and they gradually increafe in fize till they acquire the length of four or five inches, and are then called *fmelts*, or *fmoults* *. About the beginning of May, all the confiderable rivers of Scotland are full of falmon-fry. After this period, they migrate to the fea. About the middle of June, the earlieft of the fry begin to appear again in the rivers. At that time they are from twelve to fixteen inches long, and gradually augment, both in number and fize, till about the end of July or the beginning of Auguft, when they weigh from fix to nine pounds. This is a very rapid growth. But a gentleman of credit at Warrington informed Mr. Pennant of a growth ftill more rapid. A falmon, weighing feventeen pounds and three quarters, was taken on the feventh day of February. It was marked on the back, fin, and tail, with fciffars, and then turned into the river. It was retaken on the 17th day of the following month of March, and then it weighed feventeen pounds and a half. The feafon for fifhing falmon in the Tweed begins on the 30th of November, and ends on old Michaelmas day. In that fingle river, it is computed that no lefs than 208,000, at a medium, are annually caught, which, together with the products of many other rivers on both fides of Scotland, not only afford a wholefome and palatable food to the inhabitants, but form no inconfiderable article of commerce.

Herrings are likewife actuated by the migrating principle. Thefe fifhes are chiefly confined to the northern and temperate regions of the globe. They frequent the higheft latitudes, and are fometimes found on the northern coafts of France. They appear in vaft fhoals on the coaft of America, as far fouth as Carolina. In Chefapeak Bay there is an annual inundation of herrings; and Mr. Catefby informs us, that they cover the fhores in fuch amazing numbers as to become offenfive to the inhabitants. The great winter rendezvous of the herrings is within, or near, the Arctic Circle, where they remain feveral months, and acquire ftrength after being weakened by the fatigues of fpawning,

* See an account of the Salmon Fifhery on the River Tweed, communicated to Mr. Pennant by Mr. Potts, Brit. Zool. vol. 3. pag. 241. 8vo. edit. S.

ſpawning, and of a long migration. In theſe ſeas, inſect food is much more abundant than in warmer latitudes. They begin their migration ſouthward in the ſpring, and appear off the Shetland iſlands in the months of April and May. Theſe, however, are only the forerunners of the immenſe ſhoal which arrives in June. Their approach is recogniſed by particular ſigns, ſuch as the appearance of certain fiſhes, the vaſt number of birds, as gannets or ſolan geeſe, which follow the ſhoal to prey upon the herrings. But, when the main body arrives, its breadth and depth are ſo great as to change the appearance of the ocean itſelf. The ſhoal is generally divided into columns of five or ſix miles in length, and three or four in breadth. Their progreſſive motion creates a kind of rippling or ſmall undulations in the water. They ſometimes ſink and diſappear for ten or fifteen minutes, and then riſe again toward the ſurface. When the ſun ſhines, a variety of ſplendid and beautiful colours are reflected from their bodies. In their progreſs ſouthward, the firſt interruption they meet with is from the Shetland iſlands. Here the ſhoal divides into two branches. One branch ſkirts the eaſtern, and the other the weſtern ſhores of Great-Britain, and fill every bay and creek with their numbers. Thoſe which proceed to the weſt from Shetland, after viſiting the Hebrides, where the great fiſhery is carried on, move on till they are again interrupted by the north of Ireland, which obliges them to divide a ſecond time. One diviſion takes to the weſt, where they are ſcarcely perceived, being ſoon loſt in the immenſity of the Atlantic Ocean. The other diviſion goes into the Iriſh Sea, and affords nouriſhment to many thouſands of the human race. The chief object of herrings migrating ſouthward is to depoſit their ſpawn in warmer and more ſhallow ſeas than thoſe of the Frigid Zone. This inſtinct ſeems not to be prompted by a ſcarcity of food; for, when they arrive upon our coaſts, they are fat and in fine condition; but, when returning to the ocean, they are weak and emaciated. They continue in perfection from the end of June to the beginning of winter, when they begin to depoſit their ſpawn. The great ſtations of the herring fiſheries

fisheries are off the Shetland and the western islands, and along the coast of Norfolk.

Beside salmons and herrings, there are many fishes which observe a regular migration, as mackarels, lampreys, pilchards, &c. About the middle of July, the pilchards, which are a species of herrings, though smaller, appear in vast shoals off the coasts of Cornwall. When winter approaches, like the herrings, they retire to the Arctic seas. Though so nearly allied to the herring, it is not incurious to remark, that the pilchards, in their migration for the purpose of spawning, choose a warmer latitude; for, off the coasts of Britain, the great shoals never appear farther north than the county of Cornwall and the Scilly islands. Dr. Borlase, in his history of Cornwall, gives the following account of the pilchard fishery: 'It employs,' says he, 'a great number 'of men on the sea, training them thereby to naval af-'fairs; employs men, women, and children at land, in 'salting, pressing, washing, and cleaning, in making 'boats, nets, ropes, casks, and all the trades depending 'on their construction and sale. The poor is fed with 'the offals of the captures, the land with the refuse of 'the fish and salt; the merchant finds the gains of com-'mission and honest commerce, the fisherman the gains 'of the fish. Ships are often freighted hither with salt, 'and into foreign countries with the fish, carrying off, 'at the same time, part of our tin. The usual produce 'of the number of hogsheads exported each year, for 'ten years, from 1747 to 1756 inclusive, from the four 'ports of Tawy, Falmouth, Penzance, and St. Ives, it 'appears, that Tawy has exported yearly 1732 hogsheads; 'Falmouth, 14631 hogsheads and two-thirds; Penzance 'and Mounts-Bay, 12149 hogsheads and one-third; St. 'Ives, 1282 hogsheads: In all amounting to 29,795 hogs-'heads. Every hogshead, for ten years last past, together 'with the bounty allowed for each hogshead exported, 'and the oil made out of each hogshead, has amounted, 'one year with another at an average, to the price of 'one pound thirteen shillings and three pence; so that 'the

'the caſh paid for pilchards exported has, at a medium, 'annually amounted to the ſum of L.49,532:10:0.'

Of the land-crab there are ſeveral ſpecies. The migration of what is called the *violet land-crab* deſerves ſome notice. It inhabits the warmer regions of Europe: But its particular reſidence is in the tropical climates of Africa and America. Land-crabs generally frequent the mountainous parts of the country, which are, of courſe, moſt remote from the ſea. They inhabit the hollows of old trees, the clefts of rocks, and holes which they themſelves dig in the earth. They are extremely numerous. In the months of April and May, they leave their retreats in the mountains, and march in millions to the ſea-ſhore. At this period the whole ground is covered with them; and a man can hardly put down his foot without treading on them *. The object of their migration is to depoſit their ſpawn on the ſea-ſhore. In their progreſs towards the ſea, like the northern rats, the land-crabs move in a ſtraight line. Even when a houſe intervenes, inſtead of deviating to the right or left, they attempt to ſcale the walls. But, when they meet with a river, they are obliged to wind along the courſe of the ſtream. In their migration from the mountains, they obſerve the greateſt regularity, and commonly divide into three battalions, or bodies. The firſt conſiſts of the ſtrongeſt and boldeſt males, who, like pioneers, march forward to clear the route, and to face the greateſt dangers. The females, who form the main body, deſcend from the mountains in regular columns, which are fifty paces broad, three miles long, and ſo cloſe that they almoſt entirely cover the ground. Three or four days afterwards, the rear-guard follows, which conſiſts of a ſtraggling undiſciplined troop of males and females. They travel chiefly during the night; but, if it rains by day (for moiſture facilitates their motion), they proceed in their ſlow uniform manner. When the ſun ſhines, and the ſurface of the ground is dry, they make an univerſal halt till the evening, and then reſume their march. When alarmed with danger,

* Voyage aux Iſles Françoiſes, par Labat, tom. 2. pag. 221. S.

danger, they run backward in a diforderly manner, and hold up their nippers in a threatening pofture. They even feem to intimidate their enemies; for, when difturbed, they make a clattering noife with their nippers. But, though they endeavour to render themfelves formidable to their enemies, they are cruel to each other. When an individual, by any accident, is fo maimed that he cannot proceed, his companions immediately devour him, and then purfue their journey. After a fatiguing and tedious march, which fometimes continues three months before they reach the fhore, they prepare themfelves for depofiting their fpawn. The eggs ftill remain in the bodies of the animals, and are not excluded, as ufual to this genus, under the tail. To facilitate the maturation and exclufion of the eggs, the land-crabs no fooner arrive on the fhore, than they approach to the margin of the fea, and allow the waves to pafs feveral times over their bodies. They immediately retire to the land; the eggs, in the mean time, come nearer to maturity, and the animals once more go into the water, depofit their eggs, and leave the event to Nature. The bunches of fpawn are fometimes as large as a hen's egg; and it is not incurious to remark, that, at this very period, numbers of fifhes of different kinds are anxioufly waiting for this annual fupply of food. Whether the painful migration of the land-crabs, or the wonderful inftinct of the fifhes which await their arrival, in order to devour their fpawn, is the moft aftonifhing fact, we fhall leave to the confideration of philofophers. The eggs which efcape thefe voracious fifhes are hatched under the fand. Soon after, millions of minute crabs are feen leaving the fhore, and migrating flowly toward the mountains. Moft of the old ones, however, remain in the flat parts of the country till they regain their ftrength. They dig holes in the earth, the mouths of which they cover with leaves and mud. Here they throw off their old fhells, remain quite naked, and almoft without motion for fix days, when they become fo fat that they are efteemed delicious food. When the new fhell has hardened, the animals, by an inftinctive impulfe, march back to thofe mountains which they had formerly

formerly deſerted. In Jamaica, where they are numerous, the land-crabs are regarded as great delicacies; and they are ſo abundant, that the ſlaves are often fed entirely upon them.

The migrating principle is not confined to men, quadrupeds, birds, and reptiles: It extends to many of the *inſect*-tribes. Numberleſs inhabitants of the air paſs the firſt ſtages of their exiſtence in the waters. There they remain for longer or ſhorter periods, according to the ſpecies. Previous to their transformation into chryſalids, they quit the waters, and come upon dry ground, where they undergo their amazing change. Inſtead of active water-worms, they dig or find holes in the earth, where they are converted into chryſalids, or ſeemingly-inanimated beings, and, in a ſhort time, mount into the air in the form of winged inſects. Similar migrations are to be obſerved among land-inſects. But migration is not confined to water-worms. Many ſpecies of caterpillars, which feed upon the leaves of trees, ſhrubs, and other vegetables, when about to undergo their transformation, leave their former abodes, deſcend from the trees, and conceal themſelves in the earth. The hiving of bees, when numerous colonies remove in order to eſtabliſh new ſettlements, is another inſtance of the migration of inſects. Indeed, if we except bees, waſps, ants, and a few others, moſt inſects, whether they inhabit the air, the earth, or the waters, are perfect wanderers, having no fixed place of reſidence. Some of them, as the ſpider-tribes, build temporary apartments; but, when diſturbed, they migrate to another commodious place, and erect new habitations.

From the facts which have been enumerated, it is apparent, that the principle of migration, or the deſire of changing ſituations, is not confined to particular birds, but extends through almoſt the whole ſyſtem of animation. Men, quadrupeds, birds, fiſhes, reptiles, inſects, all afford ſtriking examples of the migrating principle. From the ſame facts it is equally apparent, that the general motives for migrating are ſimilar in every claſs of animals. Food, multiplication of ſpecies, and a comfortable

tempe-

temperature of air, are evidently the chief caufes which induce animals to remove from one place to another, or, what amounts to the fame thing, from one climate to another. Partial emigrations, or emigrations to fmall diftances, are prompted by the fame inftinctive motives which induce animals of a different ftructure to undertake long and fatiguing excurfions. But, previous to actual migration, what are the peculiar feelings of different animals, and what fhould ftimulate them to proceed uniformly in the direction that ultimately leads them to the fituations moft accommodated to their wants and their conftitutions, are myfteries, with regard to which, like every other part of the œconomy of Nature, it is the duty of philofophers, inftead of attempting to pufh their inquiries beyond the bounds of human ability, to obferve a refpectable filence.

CHAPTER XXI.

Of the Longevity and Diffolution of Organifed Bodies.

IT is a law of Nature, though a melancholy one, that all organifed bodies fhould be diffolved. The periods of diffolution, however, are as various as the fpecies, and the intentions of Nature in producing them.

In the human kind, the brevity of life is regarded as an object of regret. One half of mankind die before they arrive at eight years of age. From that early period to eighty, befide the deftruction of war, and other accidents, Nature kills them annually in millions. Some inftances may be given of men whofe lives were prolonged beyond the ufual period of human exiftence. Such men are not to be envied; nor fhould they be confidered as favourites of Nature. With refpect to maturity of judgment, and a knowledge of the world, no man can be faid

to exiſt till he paſſes thirty years of age. Give him thirty or thirty-five more, and, in general, both mind and body are viſibly declined. Theſe people, therefore, who arrive at an extraordinary age, may be ſaid to exiſt, but they do not live. All intellectual enjoyments and exertions, which conſtitute the chief dignity and happineſs of man, are gone. There are exceptions; but theſe exceptions are confirmations of what we have advanced. Mankind, in the early ages of the world, have been ſaid to live for ſeveral centuries. We mean not to contradict the aſſertion. But we muſt remark, that, if ever men lived ſo long, they muſt have been very different, both in the ſtructure of their bodies and in their manners, from thoſe who now exiſt. From infancy to manhood, there is a gradual growth or extenſion of our organs. After this period, and when we advance in years, the bones harden, the muſcles turn ſtiff, the cartilages are converted into bones, the membranes into cartilages, the ſtomach and bowels loſe their tone, and the whole fabrick, inſtead of being ſoft, flexible, and obedient to the inclinations, or even the commands, of the mind, becomes rigid, inactive, and feeble. Theſe are the general and progreſſive cauſes of death, and they are common to all animals. There are modes of living more favourable to health than others. But examples are not wanting of men who have arrived at an extreme old age, without obſerving either temperance, or any of the other modes of living which are generally ſuppoſed to be favourable to longevity. Some men, who lived temperately, and even abſtemiouſly, have reached to great ages; Others, who obſerved the very oppoſite conduct, who lived freely and often intemperately, have had their exiſtence equally prolonged. But, in general, notwithſtanding a few exceptions, temperance, a placid and chearful diſpoſition, moderate exerciſe, and proper exertions of mind, contribute, in no uncommon degree, to the prolongation of life.

A few examples of longevity in the human ſpecies, though no general concluſions can be drawn from them, may not be incurious to the reader. We ſhall not go back to a remote and obſcure antiquity, but confine our-

ſelves

ſelves to more modern times, when the modes of living were nearly the ſame as they are at preſent.

On this ſubject, the celebrated Lord Verulam, in his Sylva Sylvarum*, gives the following paſſage, chiefly tranſlated from the ſeventh book of Pliny's Natural Hiſtory: 'The year of our Lord ſeventy-ſix, falling into the 'time of Veſpaſian, is memorable; in which we ſhall 'find, as it were, a kalendar of long-lived men: For 'that year there was a taxing, (now a taxing is the moſt 'authentical and trueſt informer touching the ages of 'men), and in that part of Italy which lieth between 'the Appennine mountains and the river Po, there were 'found 124 perſons that either equalled or exceeded an 'hundred years of age, namely,

'Fifty-four - -	of 100 years each.
'Fifty-ſeven - -	110
'Two - - -	125
'Four - - - -	130
'Four - - -	135 or 137
'Three - - - -	140

'Beſide theſe, Parma, in particular, afforded five, whereof,

'Three were - -	120 years each.
'Two - -	130
'One in Bruxelles -	125
'One in Placentia - -	131
'One in Faventia - -	132

'A certain town, then called the Velleiatium, ſituate in 'the hills about Placentia, afforded ten, whereof

'Six were - -	110 years each.
'Four - - -	120
'One in Rimino, whoſe name 'was Marcus Aponius -	150.'

The moſt extraordinary inſtance of longevity in Great Britain was exhibited in the perſon of Henry Jenkins. He was a native of Yorkſhire, lived to the amazing age of 169 years, and died on the 8th day of December 1670.

Next to Jenkins, we have the famous Thomas Parre, who was a native of Shropſhire, and died on the 16th day of November 1635, at the age of 152.

Francis

* Page 293. S.

Francis Confist, a native of Yorkshire, aged 150, died in January 1768.

Margaret Forster, aged 136, and her daughter, aged 104, were natives of Cumberland, and both alive in the year 1771.

William Evans, aged 145, lived in Carnarvon, and still existed in the year 1782.

Dumiter Radaloy, aged 140, lived in Harmenstead, and died on the 16th day of January 1782.

James Bowels, aged 152, lived in Kilingworth, and died on the 15th day of August 1656.

The Countess of Desmond, in Ireland, saw her 140th year.

Mr. Ecleston, a native of Ireland, lived to the age of 143, and died in the year 1691.

John Mount, a native of Scotland, saw his 136th year, and died on the 27th day of February 1776.

William Ellis of Liverpool died on the 16th day of August 1780, at the age of 130.

Colonel Thomas Winsloe, a native of Ireland, aged 146, died on the 22d day of August 1766.

John Taylor was born in Carrygill, in the county of Cumberland. He was bred a miner. His father died when John was only four years of age. Poverty obliged him to be set early to work. During two years he dressed lead ore for 2d. a-day. The next three or four years he assisted the miners in removing the ore and rubbish to the bank, for which he received 4d. a-day. At this period there happened a great solar eclipse, which was distinguished in Scotland by the appellation of *Mirk Monday* *. This event, which he always repeated with the same circumstances, is the chief æra from which John's age has been computed. After labouring many years both in this and the neighbouring kingdom, he died, near Lead-hills in Scotland, in the month of May 1770, at the great age of 133.

Though the above modern examples of extraordinary longevity rest chiefly on the authority of periodical publications,

* *Mirk*, in the Scottish dialect, signifies *dark*; and the eclipse happened in the year 1652. S.

lications, yet there is not a doubt, that, in all countries, and at all times, ſome perſons of both ſexes have arrived at ages far beyond the common periods of human life. If the reader is deſirous of ſeeing many inſtances of longevity, he may conſult Bacon's *Hiſtory of Life and Death* †, Whitehurſt's *Inquiry into the Original State and Formation of the Earth* ||, and Dr. Fothergill's *Obſervations on Longevity* §.

The general cauſes of death have already been mentioned. But, in women, the operation of theſe cauſes is frequently retarded. In the female ſex, the bones, the cartilages, the muſcles, as well as every other part of the body, are ſofter and leſs ſolid than thoſe of the men: Neither are they generally ſo much ſubjected to bodily exertions. Their conſtituent parts, accordingly, require more time in hardening to that degree which occaſions death. Women, of courſe, ought to live longer than men. This reaſoning is confirmed by the bills of mortality; for, upon conſulting them, it appears, that, after women have paſſed a certain time, they live much longer than men who have reached the ſame period. The duration of the lives of animals may, in ſome meaſure, be eſtimated by the time occupied in their growth. An animal, or even a plant, as we learn from experience, which acquires maturity in a ſhort time, periſhes much ſooner than thoſe which are longer in arriving at that period. In the human ſpecies, when individuals grow with uncommon rapidity, they generally die young. This circumſtance ſeems to have given riſe to the common proverbial expreſſion, *Soon ripe ſoon rotten.* Man grows in ſtature till he be ſixteen or eighteen years of age; but the thickneſs of his body is not completely unfolded before that of thirty. Dogs acquire their full length in one year; but their growth in thickneſs is not finiſhed till the end of the ſecond. A man, who continues to grow for thirty years, may live ninety or a hundred: But a dog, whoſe growth terminates in two or three years, lives only ten

† Sylva Sylvarum, pag. 273, &c. S.

|| 2d. edit. pag. 165. S.

§ Annual Regiſter, Natural Hiſtory diviſion, pag. 61. S.

ten or twelve years. The ſame obſervation is applicable to moſt animals. Fiſhes continue to grow for a great number of years. Some of them, accordingly, live during ſeveral centuries; becauſe their bones and cartilages ſeldom acquire the denſity of thoſe of other animals. It may, therefore, be conſidered as a general fact, that large animals live longer than ſmall ones, becauſe the former require more time to complete their growth. Thus the cauſes of our diſſolution are inevitable; and it is equally impoſſible to retard that fatal period, as to change the eſtabliſhed laws of Nature. When the conſtitution is ſound, life may, perhaps, by moderating the paſſions, and by temperance, be prolonged for a few years. But the varieties of climate, and of the modes of living, make no material differences with regard to the period of our exiſtence, which is nearly the ſame in the European, the Negro, the Aſiatic, the American, the civilized man and the ſavage, the rich and the poor, the citizen and the peaſant. Neither does the difference of food, or of accommodation, make any change on the duration of life. Men who are fed on raw fleſh or dried fiſh, on ſago or rice, on caſſada or roots, live as long as thoſe who uſe bread and prepared victuals. If luxury and intemperance be excepted, nothing can alter thoſe laws of mechaniſm which invariably determine the number of our years. Any little differences which may be remarked in the term of human life, ſeem to be chiefly owing to the quality of the air. In general, there are more old men in high than in low countries. The mountains of Scotland, of Wales, and of Switzerland, have furniſhed more examples of longevity than the plains of Holland, Flanders, Germany, or Poland. But, if we take a ſurvey of mankind, whatever be the climate they inhabit, or their mode of living, there is ſcarcely any difference in the duration of life. When men are not cut off by accidental diſeaſes, individuals may every where be found who live ninety or a hundred years. Our anceſtors, with few exceptions, never exceeded this period; and, ſince the days of David King of the Jews, it has undergone no variation. Beſide accidental diſeaſes, which are more frequent, as well as more

more dangerous, in the latter periods of life, old men are ſubjected to natural infirmities that originate ſolely from a decay of the different parts of the body. The muſcles loſe their tone, the head ſhakes, the hands tremble, the limbs totter, the ſenſibility of the nerves is blunted, the cavities of the veſſels contract, the ſecretory organs are obſtructed, the blood, the lymph, and the other fluids, extravaſate, and produce all thoſe ſymptoms and diſeaſes which are commonly aſcribed to a vitiation of the humours. The natural decay of the ſolids, however, appears to be the original cauſe of all theſe maladies. It is true, that a bad ſtate of the fluids proceeds from a depravity in the organization of the ſolids. But the effects reſulting from a noxious change in the fluids produce the moſt alarming ſymptoms. When the fluids ſtagnate, or if, by a relaxation of the veſſels, an extravaſation takes place, they ſoon corrupt, and corrode the weaker parts of the ſolids. Hence the cauſes of diſſolution gradually, but perpetually, multiply, our internal enemies grow more and more powerful, and at laſt put a period to our exiſtence.

With regard to *Quadrupeds*, the cauſes of their diſſolution are preciſely the ſame with thoſe which deſtroy the human ſpecies. The times of their growth bear, likewiſe, ſome proportion to the duration of their lives. But, as we have already given a Table of the ages at which different quadrupeds are capable of multiplying their ſpecies, and of the general duration of their lives, to avoid unneceſſary repetitions, we muſt refer the reader to page 255 of this work.

Some *Birds* afford inſtances of great longevity. In this claſs of animals, the duration of life is by no means proportioned to the times of their growth. Moſt of them acquire their full dimenſions in a few months, and are capable of multiplying the ſpecies the firſt ſpring or ſummer after they are hatched. In proportion to the ſize of their bodies, birds are much more vivacious, and live longer than either men or quadrupeds. Swans have been ſaid to live three hundred years; but, though mentioned by reſpectable writers, the aſſertion is not ſupported by any

any authentic evidence. Mr. Willoughby, in his Ornithology*, remarks, ‘ We have been aſſured by a friend ‘ of ours, a perſon of very good credit, that his father ‘ kept a gooſe known to be fourſcore years of age, and ‘ as yet ſound and luſty, and like enough to have lived ‘ many years longer, had he not been forced to kill her ‘ for her miſchievouſneſs, worrying and deſtroying the ‘ young geeſe and goſlings.’ In another part of his valuable work, Mr. Willoughby tells us, ‘ that he has been ‘ aſſured by credible perſons, that a gooſe will live a hun- ‘ dred years and more †.’ In man and quadrupeds, the duration of life bears ſome proportion to the times of their growth. But, in birds, their growth, and their powers of reproduction, are more rapid, though they live proportionally longer. Some ſpecies of birds, as all the gallinaceous tribes, can make uſe of their limbs the moment they iſſue from the ſhell; and, in a month or five weeks after, they can likewiſe employ their wings. A dung-hill cock has the capacity of engendering at the age of four months, but does not acquire his full growth in leſs than a year. The ſmaller birds are perfect in four or five months. They grow more rapidly, and produce much ſooner than quadrupeds, and yet they live proportionally much longer. In man and quadrupeds, the duration of life is about ſix or ſeven times more than that of their growth. According to this rule, a cock or a parrot, who arrive at their full growth and powers in one year, ſhould not live above ſix or ſeven. But Nature knows none of our rules. She accommodates her conduct, not to our ſhallow, and often preſumptuous, concluſions, but to the preſervation of ſpecies, and to the ſupport and general balance of the great ſyſtem of animated beings. Ravens, though capable of providing for themſelves in leſs than a year, ſometimes have their lives protracted more than a century. The Count de Buffon informs us, that, in ſeveral places in France, ravens have been known to arrive at this extraordinary age, and that, at all times, and in all countries, they have been eſteemed birds of great longevity‡.

‘ Eagles,’

* Page 14. S. † Ornithology, page 256. S.

‡ Hiſt. Nat. des Oiſeaux, tom 3. page 32. S.

'Eagles,' ſays Mr. Pennant, 'are remarkable for their 'longevity, and for their power of ſuſtaining a long abſti- 'nence from food. A golden eagle, which has now been 'nine years in poſſeſſion of Owen Holland, Eſq. of Conway, 'lived thirty-two years with the gentleman who made 'him a preſent of it; but what its age was when the lat- 'ter received it from Ireland is unknown. The ſame bird 'alſo furniſhes a proof of the truth of the other remark, 'having once, through the neglect of ſervants, endured 'hunger for twenty-one days, without any ſuſtenance 'whatſoever*.' The pelican that was kept at Mechlin in Brabant during the reign of the Emperor Maximilian, was believed to be eighty years of age. 'What is re- 'ported of the age of eagles and ravens,' ſays Mr. Wil- loughby, 'although it exceeds all belief, yet doth it evince 'that thoſe birds are very long-lived†.' Pigeons have been known to live from twenty to twenty-two years. Even the ſmaller birds live very long in proportion to the time of their growth and the ſize of their bodies. Lin- nets, gold-finches, &c. often live in cages fifteen, twenty, and even twenty-three years.

Fiſhes, whoſe bones are more cartilaginous than thoſe of men and quadrupeds, are long of acquiring their ut- moſt growth, and many of them live to great ages. Geſ- ner gives an inſtance of a carp in Germany which he knew to be one hundred years old‡. Buffon informs us, that, in the Count Maurepa's ponds, he had ſeen carps of one hundred and fifty years of age, and that the fact was atteſted in the moſt ſatisfactory manner. He even mentions one which he ſuppoſed to be two hundred years old‖. Two methods have been deviſed for aſcertaining the age of fiſhes, namely, by the circles of the ſcales, and by a tranſverſe ſection of the back-bone. When a ſcale of a fiſh is examined by the microſcope, it is found to conſiſt of a number of circles within one another, re- ſembling, in ſome meaſure, thoſe rings that appear on the

 tranſverſe

* Britiſh Zoology, vol. 1. 8vo edit. page 123. S.
† Ornithology. page 14. S.
‡ Geſner de Piſc. page 312. S.
‖ Epoques de la Nature, page 181. S.

tranſverſe ſections of trees, by which their ages are computed. In the ſame manner, the ages of fiſhes may be aſcertained by the number of circles on their ſcales, reckoning for each ring one year of the animal's exiſtence. The ages of Buffon's carps were chiefly determined by the circles on their ſcales. The age of fiſhes that want ſcales, as the ſkate and ray-kind, may be pretty exactly known by ſeparating the joints of the back-bone, and obſerving minutely the number of rings which the ſurface exhibits. Both of theſe methods may be liable to deception; but they are the only natural ones which have hitherto been diſcovered. The longevity of fiſhes has been aſcribed to ſeveral cauſes. The element in which they live is more uniform, and leſs ſubject to accidental changes than the air of our atmoſphere. Their bones, which are more of a cartilaginous nature than thoſe of land-animals, admit of indefinite extenſion; of courſe, their bodies, inſtead of ſuffering the rigidity of age at an early period, which is the natural cauſe of death, continue to grow much longer than thoſe of moſt land-animals.

As to the age of *Reptiles*, probably from the unintereſting nature of the animals, we have very little information. But two letters of J. Arſcott, Eſq. of Tehott in Devonſhire, concerning the longevity of a *toad*, deſerve ſome notice. Theſe letters were addreſſed to Dr. Milles, Dean of Exeter, and by him communicated to Mr. Pennant in the year 1768: 'It would give me the greateſt 'pleaſure,' ſays Mr. Arſcott, 'to be able to inform you 'of any particulars worthy Mr. Pennant's notice, con- 'cerning the toad who lived ſo many years with us, and 'was ſo great a favourite.—It had frequented ſome ſteps 'before the hall-door ſome years before my acquaintance 'commenced with it, and had been admired by my fa- 'ther for its ſize, (which was of the largeſt I ever met 'with), who conſtantly paid it a viſit every evening. I 'knew it myſelf above *thirty* years, and, by conſtantly 'feeding it, brought it to be ſo tame, that it always came 'to the candle, and looked up, as if expecting to be ta- 'ken up and brought upon the table, where I always fed

'it

'it with infects of all forts.—You may imagine that a toad, 'generally detefted, (although one of the moft inoffenfive 'of all animals), fo much taken notice of and befriend- 'ed, excited the curiofity of all comers to the houfe, 'who all defired to fee it fed; fo that even ladies fo far 'conquered the horrors inftilled into them by nurfes, as 'to defire to fee it *.' In the fecond letter, Mr. Arfcott remarks, 'I cannot fay how long my father had been ac- 'quainted with the toad before I knew it; but, when I 'was firft acquainted with it, he ufed to mention it as the 'old toad I have known fo many years; I can anfwer for '*thirty-fix* years †.'—'In refpect to its end, had it not 'been for a tame raven, I make no doubt it would have 'been now living, who, one day, feeing it at the mouth 'of its hole, pulled it out, and, though I refcued it, pull- 'ed out one eye, and hurt it fo, that, notwithftanding its 'living a twelvemonth, it never enjoyed itfelf, and had a 'difficulty in taking its food, miffing the mark for want 'of its eye. Before that accident it had all the appear- 'ance of perfect health ‡.'

Moft *Infects*, efpecially after their laft transformation, are fhort-lived. But the fpecies are continually fupported by their wonderful fecundity. Thofe animals whofe parts require a long time of hardening and expanding are endowed with a proportional degree of longevity. Infects grow, and their bodies harden, more quickly than thofe of larger animals. Many of them complete their growth in a few weeks, and even in a few days. The duration of their exiftence is accordingly limited to very fhort periods. Some fpecies of flies lie in a torpid ftate during the winter, and revive when the heat of fpring or fummer returns. The ephemeron-flies, of which there are feveral kinds, feldom live above one day, or one hour, after their transformation. But, to continue the fpecies, Nature has taken care that myriads of males and females fhould be transformed nearly at the fame inftant. Were it otherwife, the males and females could have no opportunity of meeting, and the fpecies would foon be extinguifhed. Other

* Pennant's Britifh Zoology, vol. 3. pag. 323. S. † Ibid. pag. 326. S.
‡ Ibid. pag. 331. S.

Other kinds are transformed more irregularly, and live several days. Here the wisdom of Nature is conspicuous: She prolongues the existence of these animals for no other purpose but to allow the individuals of both sexes to meet and multiply the species. Bees, and flies of all kinds, after lying long in water, and having every appearance of death, revive by the application of a gentle heat, or by covering their bodies with ashes, chalk, or sand, which absorb the superfluous moisture from their pores. Reaumur made many experiments upon the reviviscence of drowned bees. He found, that, after being immersed in water for nine hours, some of them returned to life; but he acknowledges that many of them, in the fourth part of this time, were actually dead, and that neither heat, nor the application of absorbent powders, could restore them to life. Analogical reasoning is often deceitful, but it frequently leads to useful truths. As flies of all kinds, after immersion in water, and exhibiting every mark of actual death, can be restored to life by covering their bodies with any absorbent substance, without the assistance of a heat superior to that of the common atmosphere, might not the ordinary methods employed for the recovery of drowned persons be assisted by the application of warm ashes or chalk? The structure of a fly and that of a man, it is allowed, are very different. But, in desperate cases, when every other method fails, no fact should be overlooked, and no analogy despised.

Plants differ as much in the periods of their existence as animals. Many plants perish yearly; others are biennial, triennial, &c. But, the longevity and magnitude of particular trees are prodigious. We are informed by Mr. Evelyn, that in the bodies of some English oaks, when cut transversely, three, and even four hundred rings of wood have been distinguished. A ring of wood is added annually to the trunks of trees; and, by counting the rings, the age of any tree may be pretty exactly ascertained *. With regard to the magnitude of oaks, some of them are huge masses. Dr. Hunter, in his Notes upon Evelyn's Sylva, remarks, that none ' of the oaks men-
' tioned

* See Evelyn's Sylva, pag. 505. S.

'tioned by Mr. Evelyn bear any proportion to one now 'growing at Cowthorpe, near Wetherby, upon an eſtate 'belonging to the Right Hon. Lady Stourton. The di'menſions are almoſt incredible. Within three feet of 'the ſurface, it meaſures ſixteen yards, and, cloſe by 'the ground, twenty-ſix yards. Its height, in its preſent 'and ruinous ſtate, (1776), is about eighty-five feet, and 'its principal limb extends ſixteen yards from the bole. '—When compared to this, all other trees are but *chil*'*dren* of the foreſt *.'

From the facts which have been enumerated, it appears, that all animals, as well as vegetables, have ſtated periods of exiſtence, and that their diſſolution is uniformly accompliſhed by a gradual hardening and deſiccation of their conſtituent parts. No art, no medicine, can retard the operations of Nature. It is, therefore, the wiſdom and the duty of every human being to ſail down the irreſiſtible current of Nature with all poſſible tranquillity and reſignation. Life, whether ſhort or long, whether fortunate or unfortunate, when the fatal period arrives, is of little conſequence to the individual. Society, knowledge, virtue, and benevolence, are our only rational enjoyments, and ought to be cultivated with diligence.

With regard to animals in general, the actual duration of their lives is very different. But the comparative ſhortneſs or length of life, in particular animals, probably depends on the quickneſs or ſlowneſs of the ideas which paſs in their minds, or of the impreſſions made upon their ſenſes. A rapid ſucceſſion of ideas or impreſſions makes time ſeem proportionally long. There is likewiſe a connection between the quickneſs and ſlowneſs of ideas, and the circulation of the blood. A man whoſe pulſe is ſlow and ſluggiſh, is generally dull and phlegmatic. Raiſe the ſame man's pulſe with wine, or any other exhilarating ſtimulus, and you immediately quicken his ſenſations, as well as the train of his ideas. In all young animals, the circulation of blood is much more rapid than after they have acquired their full growth. Young animals, accordingly, are frolickſome, vivacious, and happy. But, when

* See Evelyn's Sylva, pag. 500. S.

when their growth is completed, the motion of the blood is ſlower, and their manners, of courſe, are more ſedate, gloomy, and penſive. Another circumſtance merits attention. The circulation of the blood is ſlower or quicker in proportion to the magnitude of animals. In large animals, ſuch as man and quadrupeds, the blood moves ſlowly, and the ſucceſſion of their ideas is proportionally ſlow. In the more minute kinds, as mice, ſmall birds, ſquirrels, &c. the circulation is ſo rapid that the pulſes of their arteries cannot be counted. Now, animals of this deſcription aſtoniſh us with the quickneſs of their movements, the vivacity of their manners, and the extreme chearfulneſs of their diſpoſitions.

Reaumur, Condillac, and many other philoſophers, conſider duration as a relative idea, depending on a train of conſcious perception and ſentiment. It is certain that the natural meaſure of time depends ſolely on the ſucceſſion of our ideas. Were it poſſible for the mind to be totally occupied with a ſingle idea for a day, a week, or a month, theſe portions of time would appear to be nothing more than ſo many inſtants. Hence a philoſopher often lives as long in one day, as a clown or a ſavage does in a week or a month ſpent in mental inactivity and want of thought.

This ſubject ſhall be concluded with a ſingle remark: If it be true, and we are certain that it is ſo in part, that animals of every ſpecies, whatever be the real duration of their lives, from a ſlow or rapid ſucceſſion of ideas, and perhaps from the comparative intenſity of their enjoyments, live equally long, and enjoy an equal portion of individual happineſs, it opens a wonderful view of the great benevolence of Nature. To ſtore every portion of this globe with animal life, She has amply peopled the earth, the air, and the waters. The multifarious inhabitants of theſe elements, as to the actual duration of their lives, are extremely diverſified. But, by variation of forms, of magnitude, of rapidity of ideas, of intenſity of pleaſures, and, perhaps, of many other circumſtances, She has conferred upon the whole nearly an equal portion of happineſs.

CHAPTER XXII.

Of the Progreſſive Scale or Chain of Beings in the Univerſe.

TO men of obſervation and reflection, it is apparent, that all the beings on this earth, whether animals or vegetables, have a mutual connection and a mutual dependence on each other. There is a graduated ſcale or chain of exiſtence, not a link of which, however ſeemingly inſignificant, could be broken without affecting the whole. Superficial men, or, which is the ſame thing, men who avoid the trouble of ſerious thinking, wonder at the deſign of producing certain inſects and reptiles. But they do not conſider that the annihilation of any one of theſe ſpecies, though ſome of them are inconvenient, and even noxious to man, would make a blank in Nature, and prove deſtructive to other ſpecies, who feed upon them. Theſe, in their turn, would be the cauſe of deſtroying other ſpecies, and the ſyſtem of devaſtation would gradually proceed, till man himſelf would be extirpated, and leave this earth deſtitute of all animation.

In the chain of animals, man is unqueſtionably the chief or capital link, and from him all the other links deſcend by almoſt imperceptible gradations. As a highly-rational animal, improved with ſcience and arts, he is, in ſome meaſure, related to beings of a ſuperior order, wherever they exiſt. By contemplating the works of Nature, he even riſes to ſome faint ideas of her great Author. Why, it has been aſked, are not men endowed with the capacity and powers of angels? beings of whom we have not even a conception. With the ſame propriety, it may be aſked, Why have not beaſts the mental powers of men? Queſtions of this kind are the reſults of ignorance, which is always petulant and preſumptuous.

Every

Every creature is perfect, according to its deſtination. Raiſe or depreſs any order of beings, the whole ſyſtem, of courſe, will be deranged, and a new world would be neceſſary to contain and ſupport them. Particular orders of beings ſhould not be conſidered ſeparately, but by the rank they hold in the general ſyſtem. From man to the minuteſt animalcule which can be diſcovered by the microſcope, the chaſm ſeems to be infinite: But that chaſm is actually filled up with ſentient beings, of which the lines of diſcrimination are almoſt imperceptible. All of them poſſeſs degrees of perfection or of excellence proportioned to their ſtation in the univerſe. Even among mankind, which is a particular ſpecies, the ſcale of intellect is very extenſive. What a difference between an enlightened philoſopher and a brutal Hottentot? Still, however, Nature obſerves, for the wiſeſt purpoſes, her uniform plan of gradation. In the human ſpecies, the degrees of intelligence are extremely varied. Were all men philoſophers, the buſineſs of life could not be executed, and neither ſociety, nor even the ſpecies, could long exiſt. Induſtry, various degrees of knowledge, different diſpoſitions, and different talents, are great bonds of ſociety. The Gentoos, from certain political and religious inſtitutions, have formed their people into different caſts or ranks, out of which their poſterity can never emerge. To us, ſuch inſtitutions appear to be tyrannical, and reſtraints on the natural liberty of man. In ſome reſpects they are ſo: But they ſeem to have been originally reſults of wiſdom and obſervation; for, independently of all political inſtitutions, Nature herſelf has formed the human ſpecies into caſts or ranks. To ſome ſhe gives ſuperior genius and mental abilities; and, even of theſe, the views, the purſuits, and the taſtes, are moſt wonderfully diverſified.

In the talents and qualities of quadrupeds of the ſame ſpecies, there are often remarkable differences. Theſe differences are conſpicuous in the various races of horſes, dogs, &c. Even among the ſame races, ſome are bold, ſprightly, and ſagacious. Others are comparatively timid, phlegmatic, and dull.

Our

Our knowledge of the chain of intellectual and corporeal beings is very imperfect; but what we do know gives us exalted ideas of that variety and progreffion which reign in the univerfe. A thick cloud prevents us from recognifing the moft beautiful and magnificent parts of this immenfe chain of being. We fhall endeavour, however, to point out a few of the more obvious links of that chain, which falls under our own limited obfervation.

Man, even by his external qualities, ftands at the head of this world. His relations are more extenfive, and his form more advantageous, than thofe of any other animal. His intellectual powers, when improved by fociety and fcience, raife him fo high, that, if no degrees of excellence exifted among his own fpecies, he would leave a great void in the chain of being. Were we to confider the characters, the manners, and the genius of different nations, of different provinces and towns, and even of the members of the fame family, we fhould imagine that the fpecies of men were as various as the number of individuals. How many gradations may be traced between a ftupid Huron, or a Hottentot, and a profound philofopher? Here the diftance is immenfe; but Nature has occupied the whole by almoft infinite fhades of difcrimination.

In defcending the fcale of animation, the next ftep, it is humiliating to remark, is very fhort. Man, in his loweft condition, is evidently linked, both in the form of his body and the capacity of his mind, to the large and fmall orang-outangs. Thefe again, by another flight gradation, are connected to the apes, who, like the former, have no tails. It is wonderful that Linnæus, and many other naturalifts, fhould have overlooked this gradation in the fcale of animals, and maintained, that the ifland of Nicobar, and fome other parts of the Eaft-Indies, were inhabited by tailed men. Before thofe animals, whofe external figure has the greateft refemblance to that of man, are ornamented, or rather deformed, with tails, there are feveral fhades of difcrimination. The larger and fmaller orang-outangs, which are real brutes, have no tails. Nei-

ther are the numerous tribes of apes furnifhed with this appendage. But the believers in tailed men gravely tell us, that there is nothing furprifing in this phenomenon, becaufe a tail is only a prolongation of the *os coccygis*, which is the termination of the back-bone. They confider not, however, that, inftead of accounting for the exiftence of tailed men, they do nothing more than fubftitute a learned circumlocution for the fimple word *tail*. It is here worthy of remark, that a philofopher, who has paid little attention to natural hiftory, is perpetually liable to be deceived; and that a naturalift, I mean a nomenclator, without philofophy,. though he may be ufeful by mechanically marking diftinctions, is incapable of enriching our minds with general ideas. A proper mixture of the two is beft calculated to produce a real philofopher. From the orang-outangs and apes to the baboons, the interval is hardly perceptible. The true apes have no tails, and thofe of the baboons are very fhort. The monkeys, who form the next link, have long tails, and terminate this partial chain of imitative animals, which have fuch a deteftable refemblance to the human frame and manners.

When examining the characters by which beings are diftinguifhable from each other, we perceive that fome of them are more general, and include a greater variety than others. From this circumftance all our diftributions into claffes, orders, genera, and fpecies, are derived. Between two claffes, or two genera, however, Nature always exhibits intermediate productions fo clofely allied, that it is extremely difficult to afcertain to which of them they belong. The polypus, which multiplies by fhoots, or by fections, from its body, connects the animal to the vegetable kingdom. Thofe worms which lodge in tubes compofed of fand, feem to link the infects to the fhell and cruftaceous animals. Shell-animals and cruftaceous infects make alfo a near approach to each other. Both of them have their mufcles and inftruments of motion attached to external inftead of internal bones. From reptiles, the degrees of perfection in animal life and powers move forward

ward in a gradual but perceptible manner. The number of their organs of ſenſe, and the general conformation of their bodies, begin to have a greater analogy to the ſtructure of thoſe animals which we are accuſtomed to conſider as belonging to the more perfect kinds. The ſnake, by its form, its movements, and its mode of living, is evidently connected with the eel and the water-ſerpent. Like reptiles, moſt fiſhes are covered with ſcales, the colours and variety of which often enable us to diſtinguiſh one ſpecies from another. The forms of fiſhes are exceedingly various. Some are long and ſlender; others are broad and contracted. Some fiſhes are flat, others cylindrical, triangular, ſquare, circular, &c. The fins of fiſhes, from the medium in which they live, are analogous to the wings of birds. Like thoſe of reptiles, the heads of fiſhes are immediately connected to their bodies, without the intervention of necks. The flying fiſhes, whoſe fins reſemble the wings of bats, form one link which unites the fiſhes to the feathered tribes. Aquatic birds ſucceed, by a gentle gradation, the flying fiſhes.

In tracing the gradations from fiſhes to quadrupeds, the tranſition is almoſt imperceptible. The ſea-lion, the morſe, all the cetaceous tribes, the crocodile, the turtle, the ſeals, have ſuch a reſemblance, both in their external and internal ſtructure, to terreſtrial quadrupeds, that ſome naturaliſts, in their methodical diſtributions, have ranked them under the ſame claſs of animals. The bats and the flying ſquirrels, who traverſe the air by means of membranous inſtead of feathered wings, evidently connect quadrupeds with birds. The oſtrich, the caſſowary, and the dodo, who rather run than fly, form another link between the quadruped and the bird.

All the ſubſtances we recognize on this earth may be divided into organiſed and animated, organiſed and inanimated, and unorganiſed, or brute, matter. The whole of theſe poſſeſs degrees of perfection, of excellence, or of relative utility, proportioned to their ſtations or ranks in the univerſe. Change theſe ſtations or ranks, and another world would be neceſſary to contain and ſupport them.

them. Beings muſt not be contemplated individually, but by their rank, and the relations they have to the conſtituent parts of the general ſyſtem of Nature. Certain reſults of their natures we conſider as evils. Deſtroy theſe evils, and you annihilate the beings who complain of them. The reciprocal action of the ſolids and fluids conſtitutes life, and the continuation of this action is the natural cauſe of death. Immortality on this earth, therefore, preſuppoſes another ſyſtem; for our planet has no relation to immortal beings. Every animal, and every plant, riſes, by gentle gradations, from an embryo, or gelatinous ſtate, to a certain degree of perfection exactly proportioned to their ſeveral orders. An aſſemblage of all the orders of relative perfection conſtitutes the abſolute perfection of the whole. All the planets of this ſyſtem gravitate toward the ſun and toward each other. Our ſyſtem gravitates toward other ſyſtems, and they to ours. Thus the whole univerſe is linked together by a gradual and almoſt imperceptible chain of exiſtences both animated and inanimated. Were there no other argument in favour of the UNITY of DEITY, this uniformity of deſign, this graduated concatenation of beings, which appears not only from this chapter, but from many other parts of the book, ſeems to be perfectly irrefragable.

In contemplating Man, as at the head of thoſe animals with which we are acquainted, a thought occurred, that no ſentient being, whoſe mental powers were greatly ſuperior, could poſſibly live and be happy in this world. If ſuch a being really exiſted, his miſery would be extreme. With ſenſes more delicate and refined; with perceptions more acute and penetrating; with a taſte ſo exquiſite that the objects around him could by no means gratify it; obliged to feed upon nouriſhment too groſs for his frame; he muſt be born only to be miſerable, and the continuation of his exiſtence would be utterly impoſſible. Even in our preſent condition, the ſameneſs and inſipidity of objects and purſuits, the futility of pleaſure, and the infinite ſources of excruciating pain, are ſupported with great difficulty by cultivated and refined minds. Increaſe our ſenſibilities, continue the ſame objects and ſituation,

and

and no man could bear to live.—Let man, therefore, be contented. His ſtation, in the univerſal ſcale of Nature, is fixed by Wiſdom. Let him contemplate and admire the works of his Creator; let him fill up his rank with dignity, and conſider every partial evil as a cauſe or an effect of general good.—This is the whole duty of man.

THE END.

I N D E X.

The

C

Cauſe,

D

G

H

Intellect.

L

M

Papilio.

very fine copy

c/c